Centre
de coopération
internationale
en recherche
agronomique
pour le
développement

Limits of accuracy and improvements on the HVI cotton fiber test

Cotton, from the plant to the final product

Jean-Paul Gourlot

Cirad-ca, Cotton Technology Laboratory

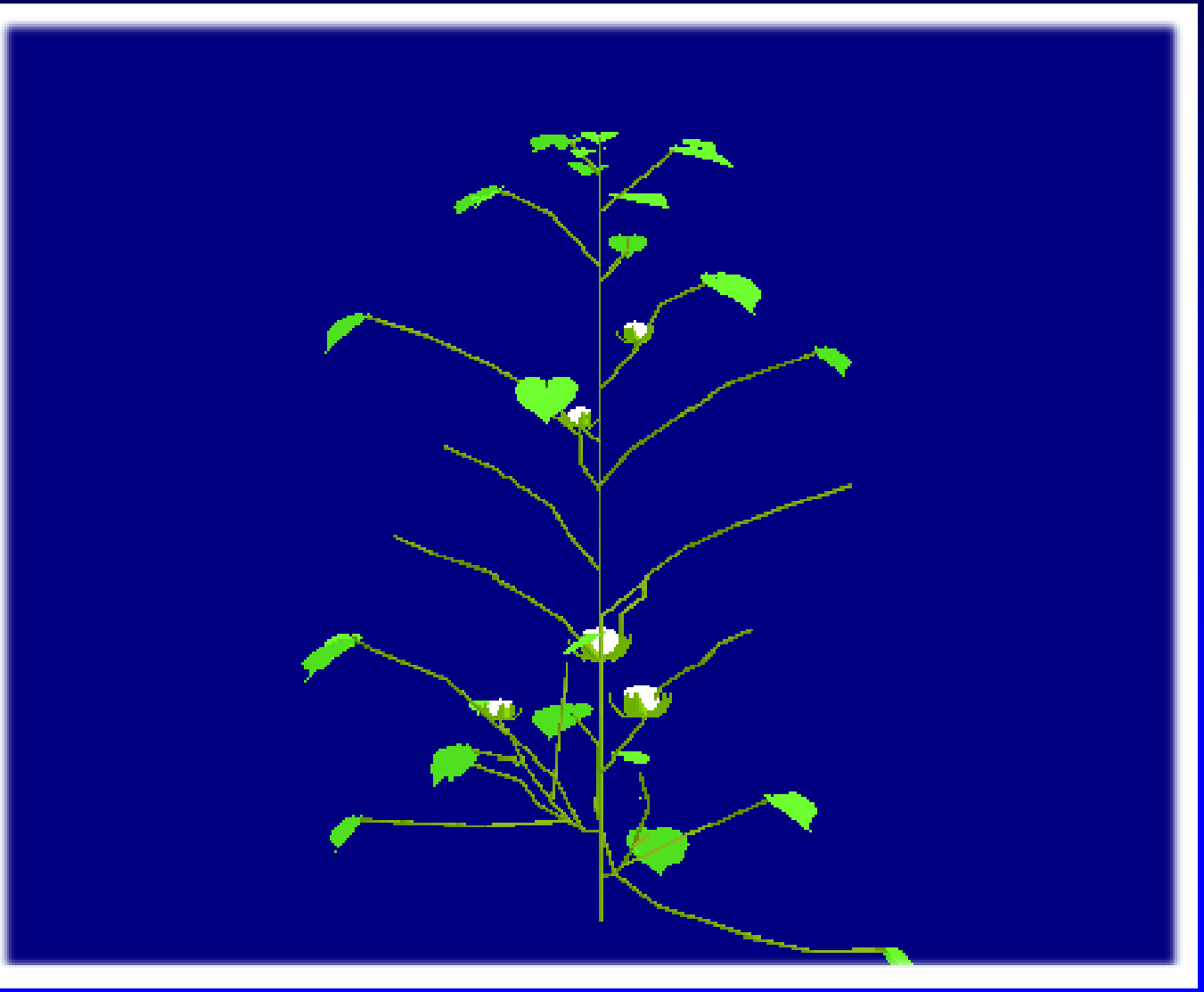
Plan of presentation

- Introduction
- Different ways of fibers characterization
- A point about the standardization process
- How does work an HVI
- An example of relation between fiber and yarn quality
- Conclusions

Cotton plant cycle

60 days

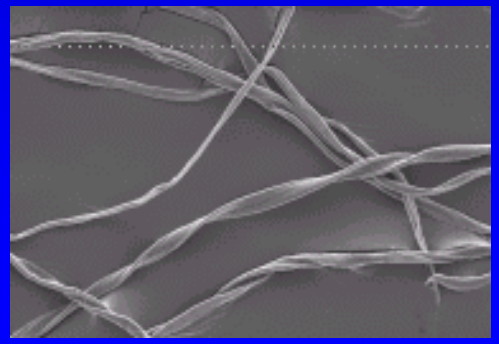
Cotton plant growth



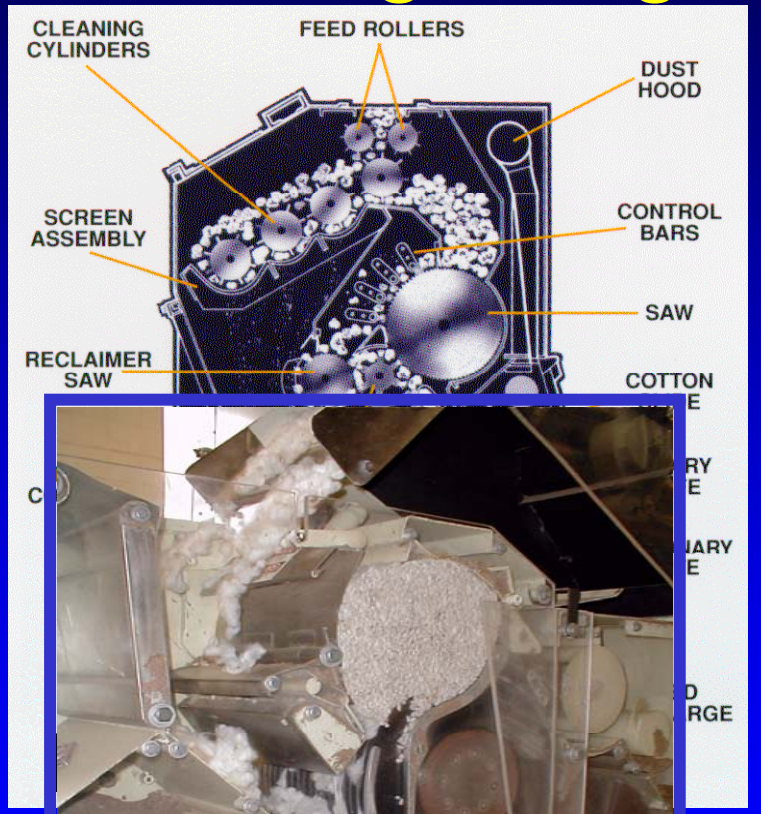
From Cirad ‘Cotons’ software

Harvesting and ginning

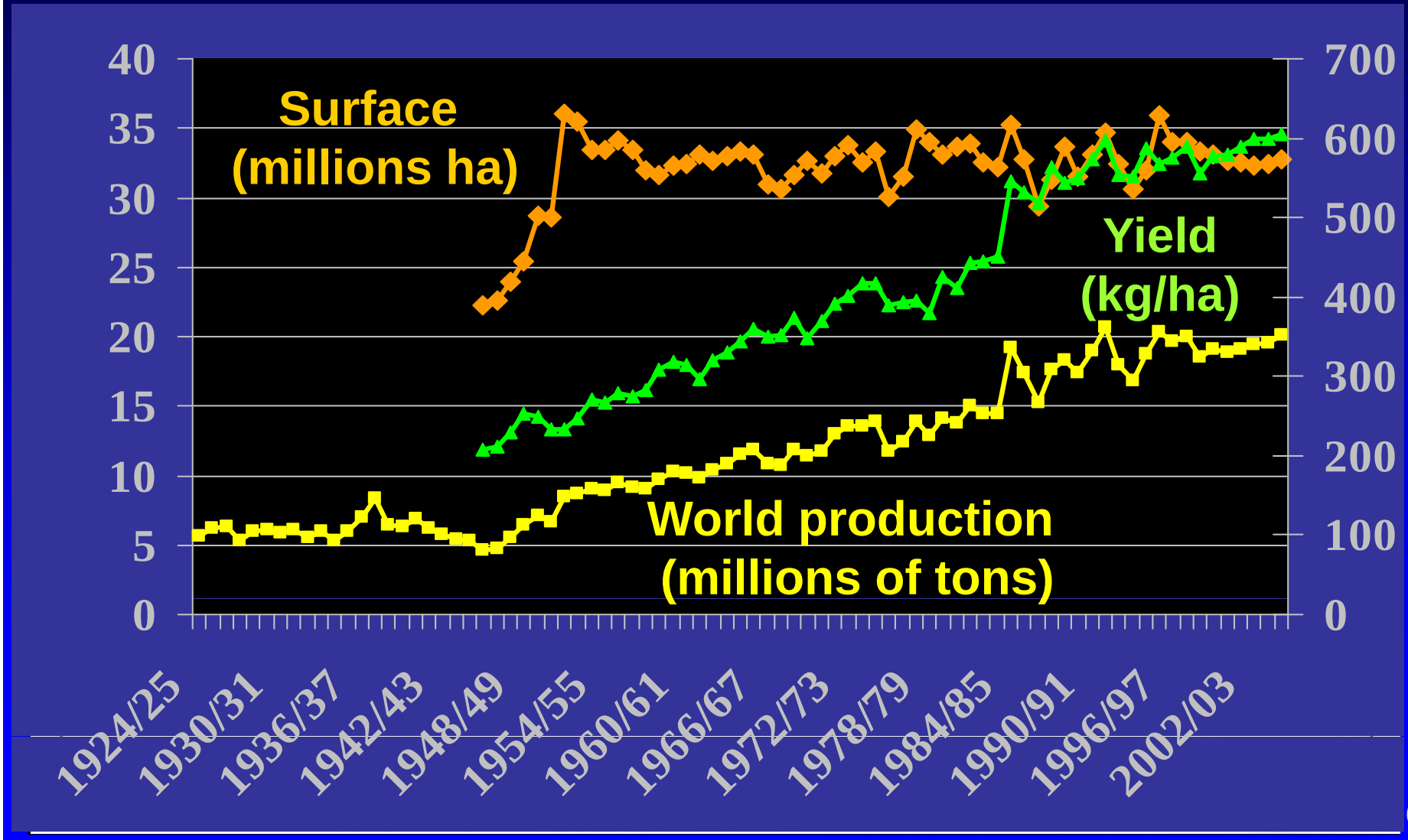
Cotton bolls harvest



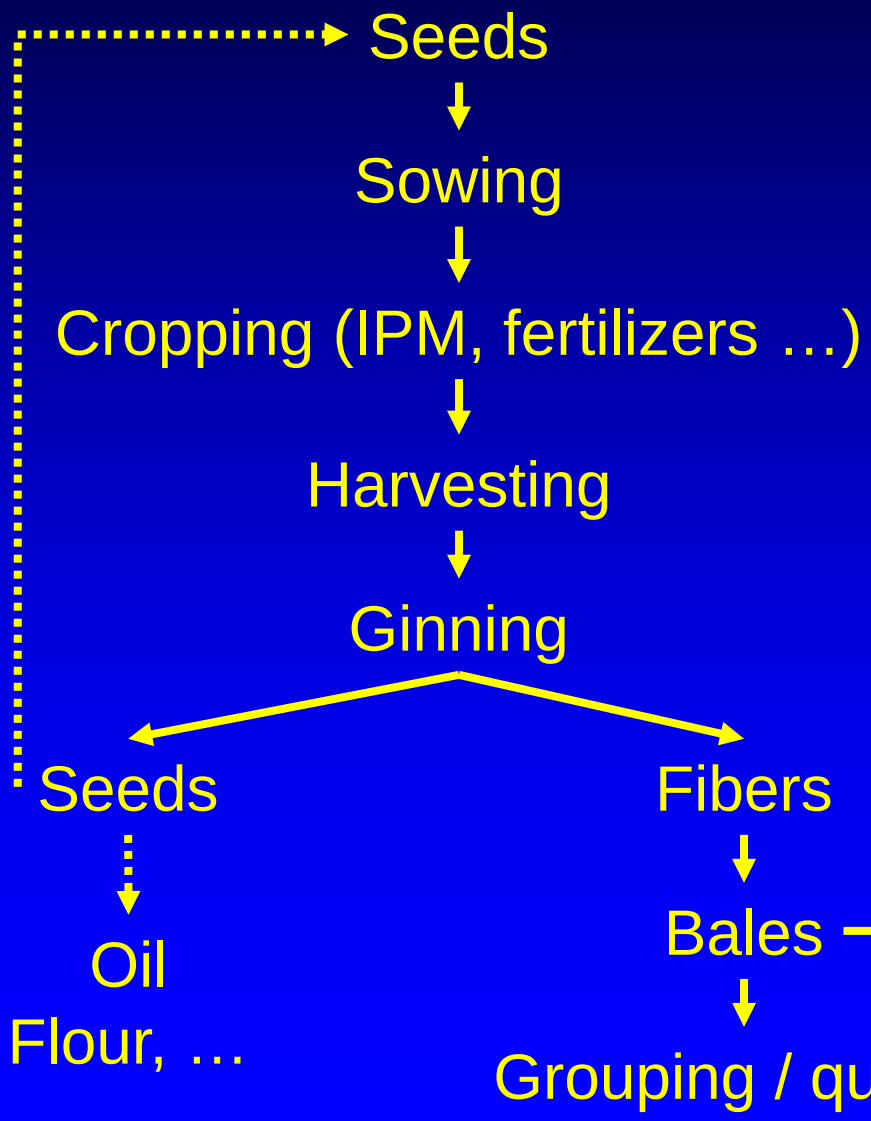
Cotton ginning



Statistics and economy



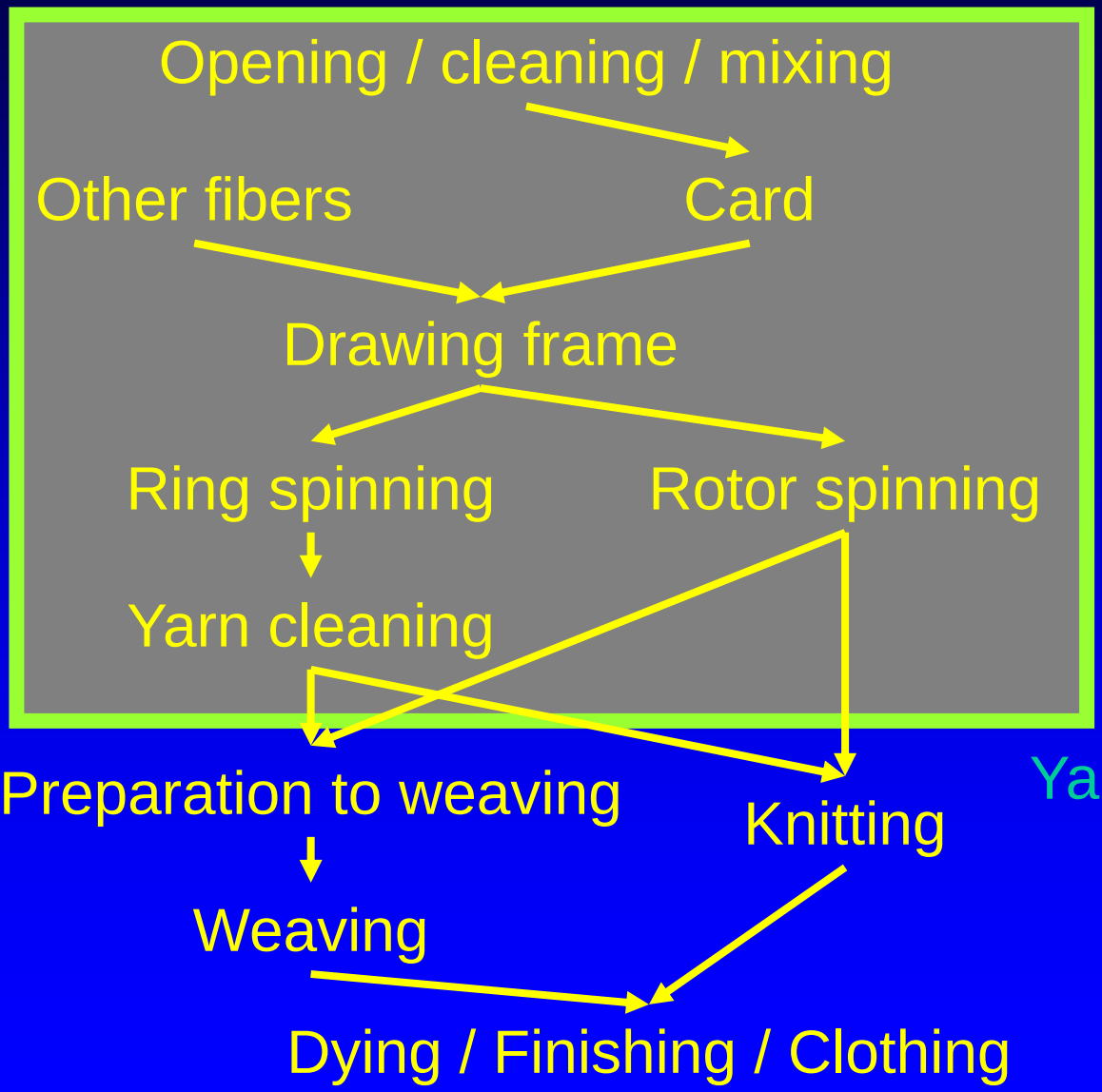
Cotton cycle* (1/3)



* From GOURLOT J.-P. et al 1999, Recherche et développement en technologie : mesurer et améliorer la qualité des produits du cotonnier, créer de nouveaux débouchés, Agriculture et développement, n°22, Juin 1999, ISSN 1249-9951, pp. 90-113.

Commercial parameters
Length, Length unif, Strength
Grade, Micronaire
Average and variability

Cotton cycle (2/3)



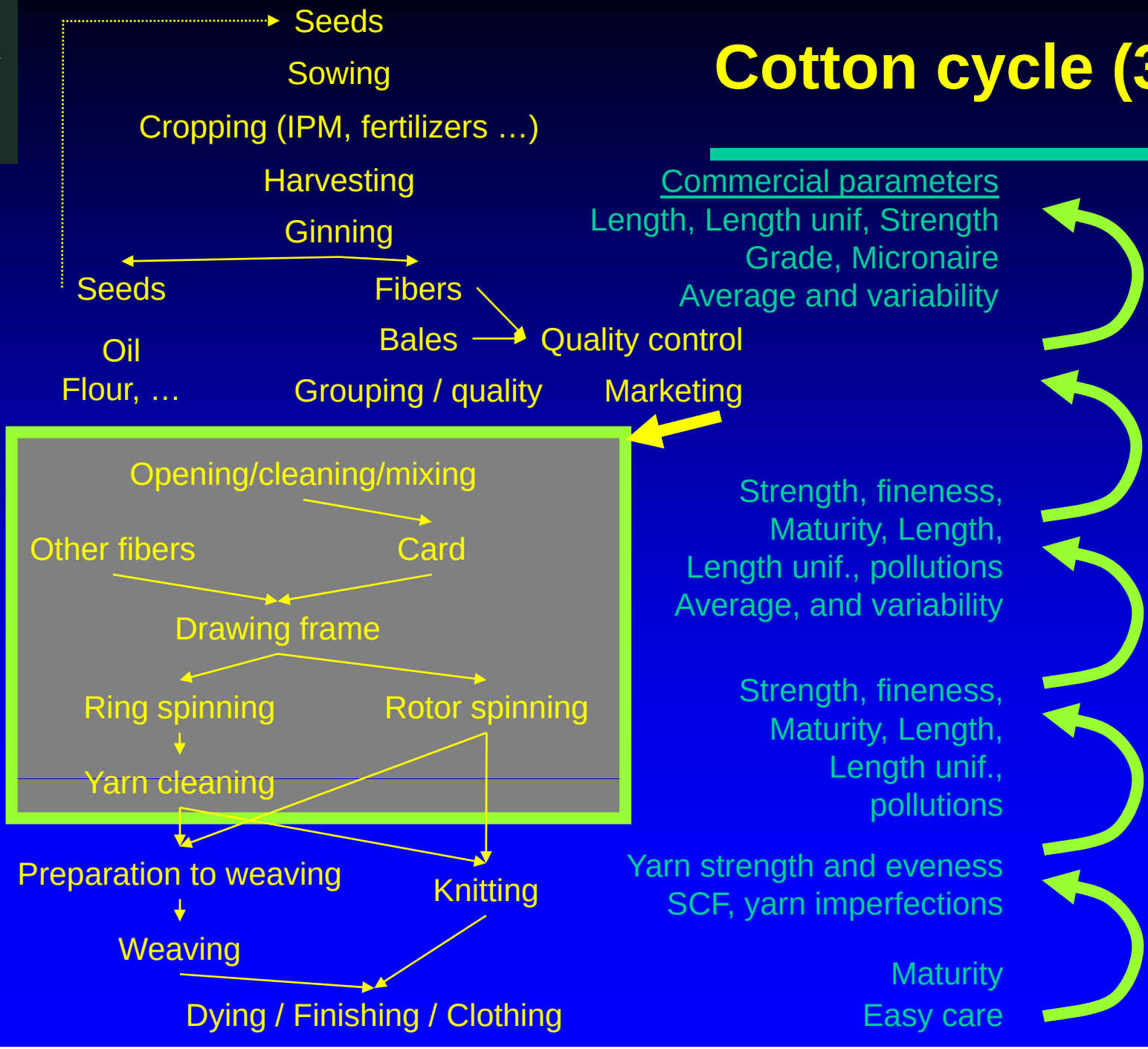
Strength, fineness, Maturity, Length, Length unif., pollutions Average, and variability

Strength, fineness, Maturity, Length, Length unif., pollutions

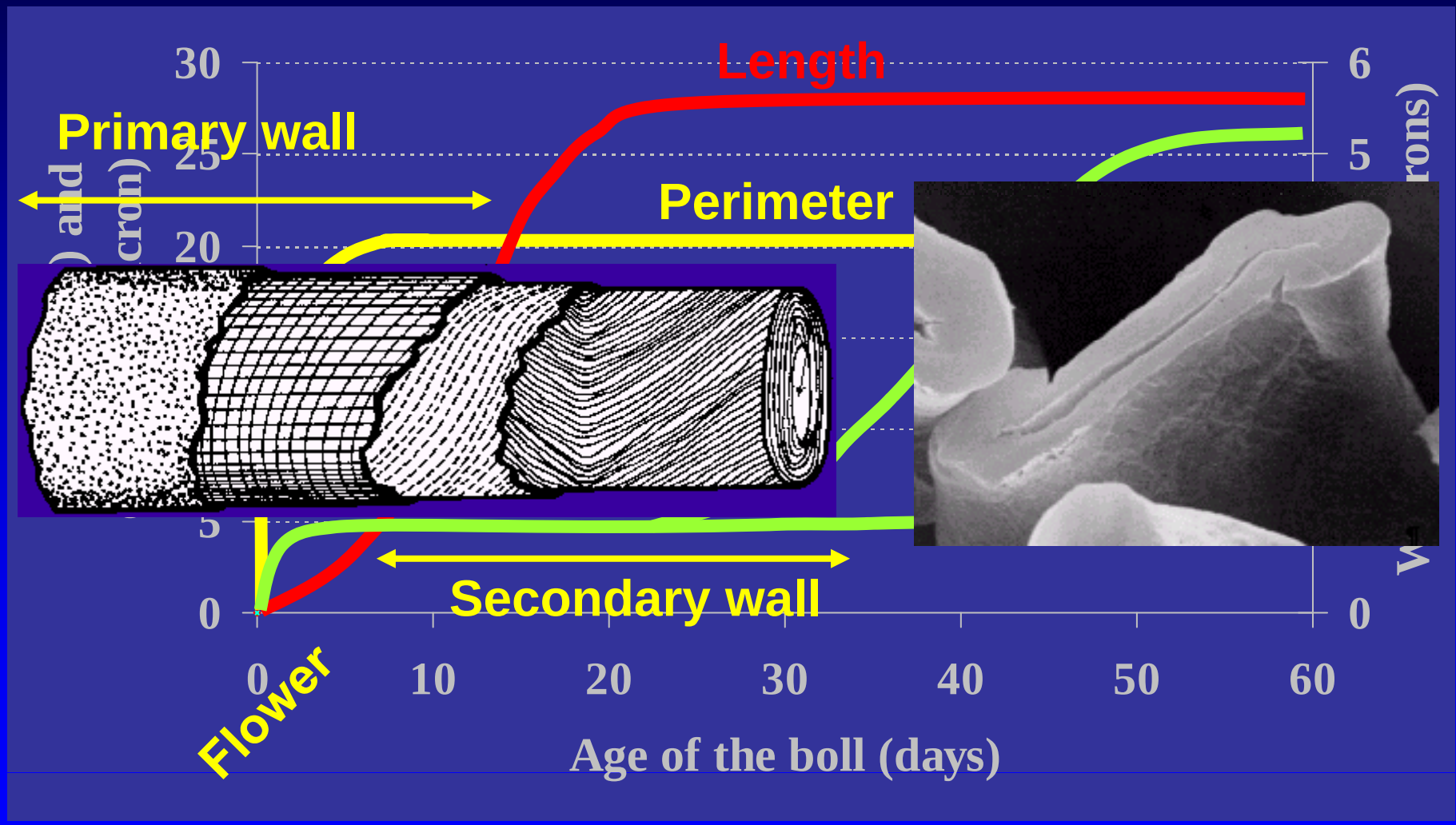
Yarn strength and eveness SCF, yarn imperfections

Maturity Easy care

Cotton cycle (3/3)



Fiber quality development

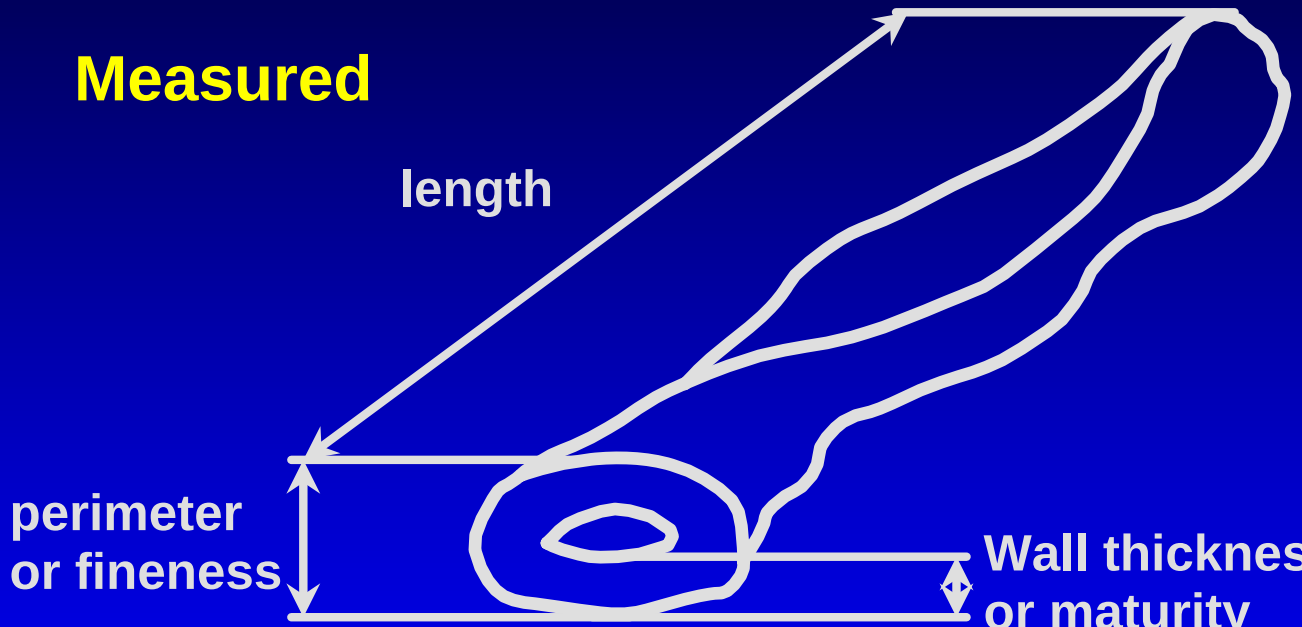


Fiber constitution

Constituants	Percentage
Cellulosis	95.0
Proteins	1.6
Waxes	0.9
Physiological sugars	0.3
Other	2.2

Fiber quality measurement

Measured



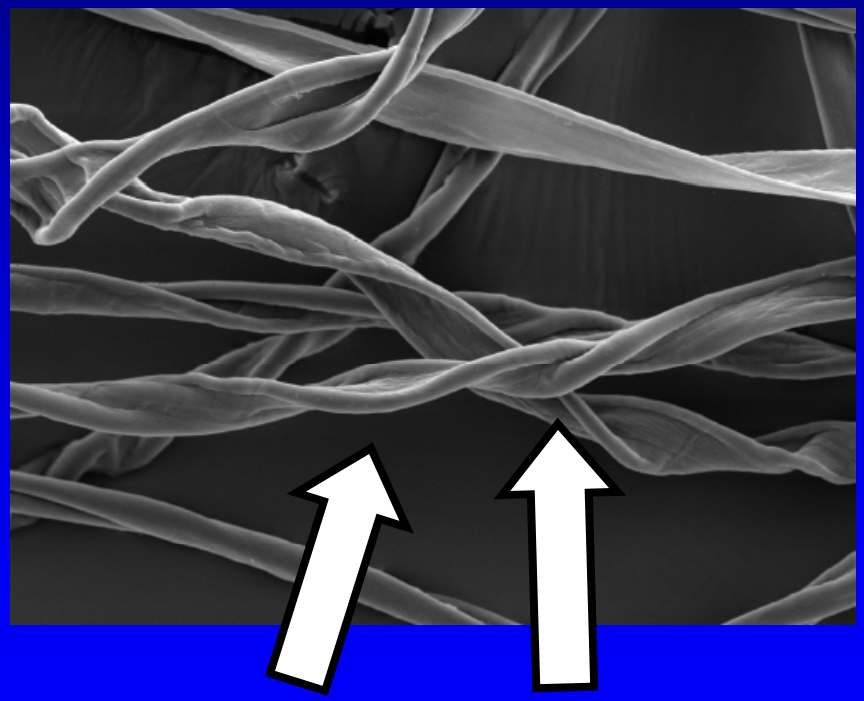
‘Micronaire’
Mike, IM

Color + contaminants
Tensile behavior

Fiber quality measurement

Could be measured

- Cellulose types
- Wax content
- Flexion / flexibility
- ‘Curling’ / crimp



Plan of presentation

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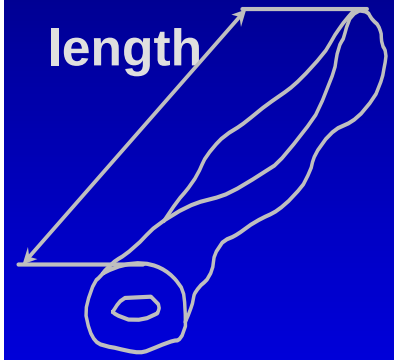
- Conclusions

Fiber quality measurement

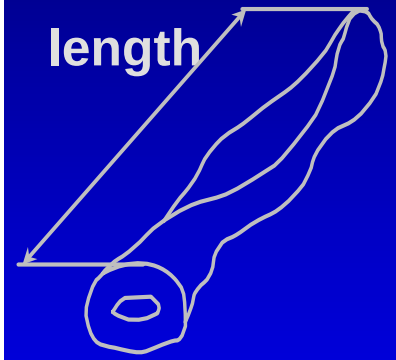
Why do we measure length ?



- Define what type of final product will be made out of the fibers
- Check the settings of ginning equipments
- Define a commercial price of the fibers
- Allow settings of the processing equipments

Fiber quality measurement

Manual :



pulling => commercial length

comb sorter => length diagrams (W, N)

=> ML, CV%, SFC Could be measured

Fiber quality measurement

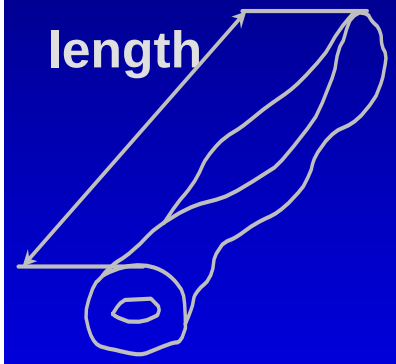
Instrumental :

<u>with classical instruments :</u>

Fibrograph => SL2.5%, SL 50%, UR%

Almeter 101 => diagrams (W, N)

=> ML, CV%, SFC



Fiber quality measurement

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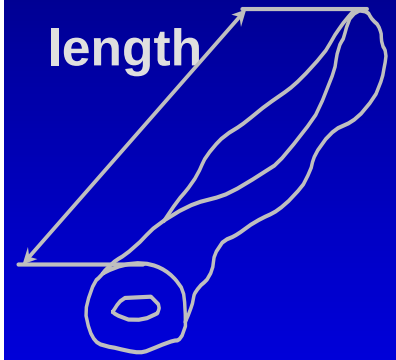

<u>with High Volume Instrument (HVI)</u>

=> UHML, ML, UI%, SFI

Fiber quality measurement

Instrumental :

<u>with classical instruments :</u>

Fibrograph => SL2.5%, SL 50%, UR%

Almeter 101 => diagrams (W, N)

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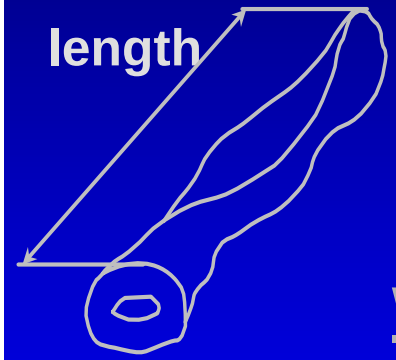
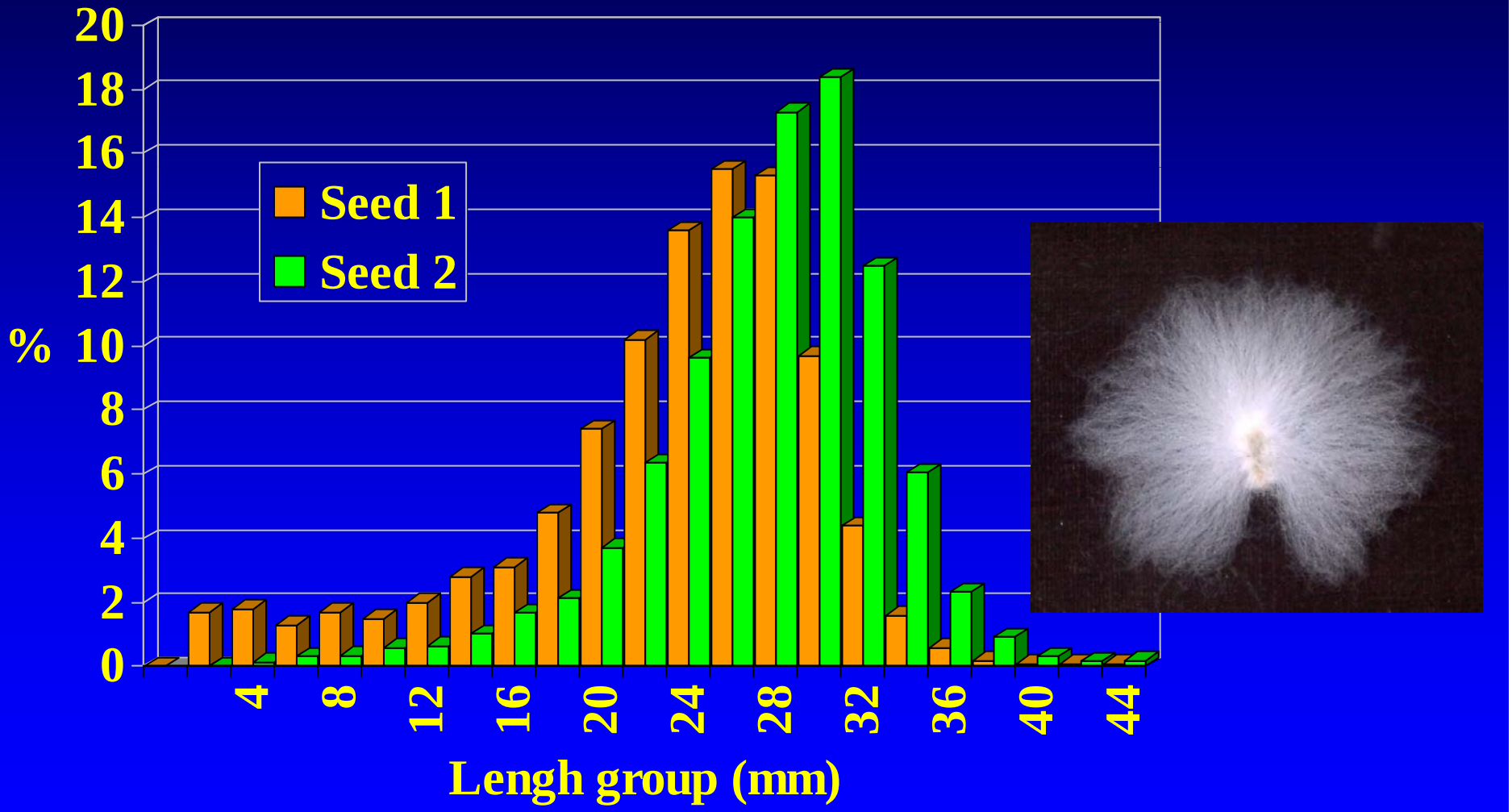


<u>with Advanced Fiber Information System (AFIS)</u>

length (W, N)

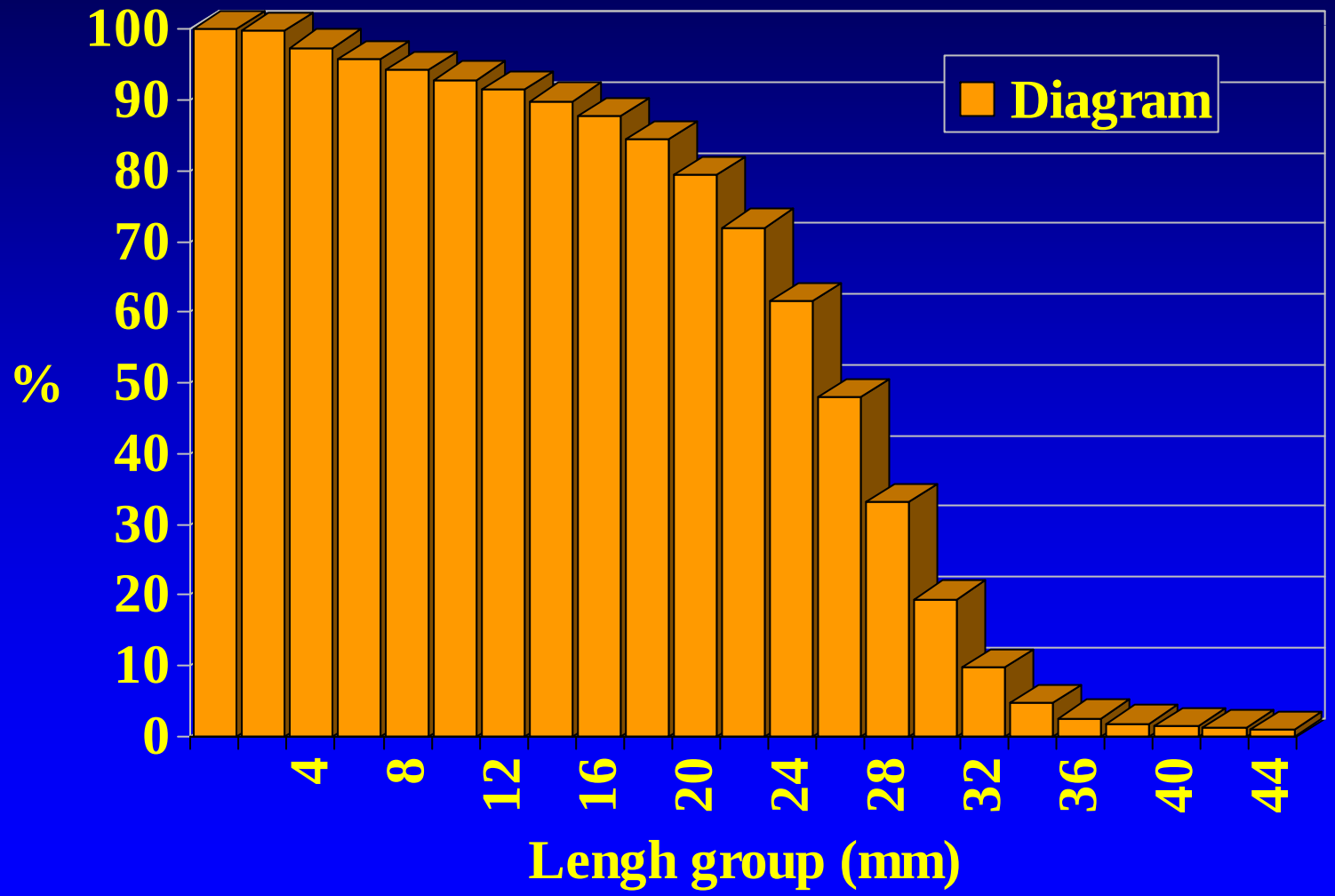
=> ML, CV, UQL, SFC

Fiber quality measurement
Length histograms on 2 seeds (AFIS)

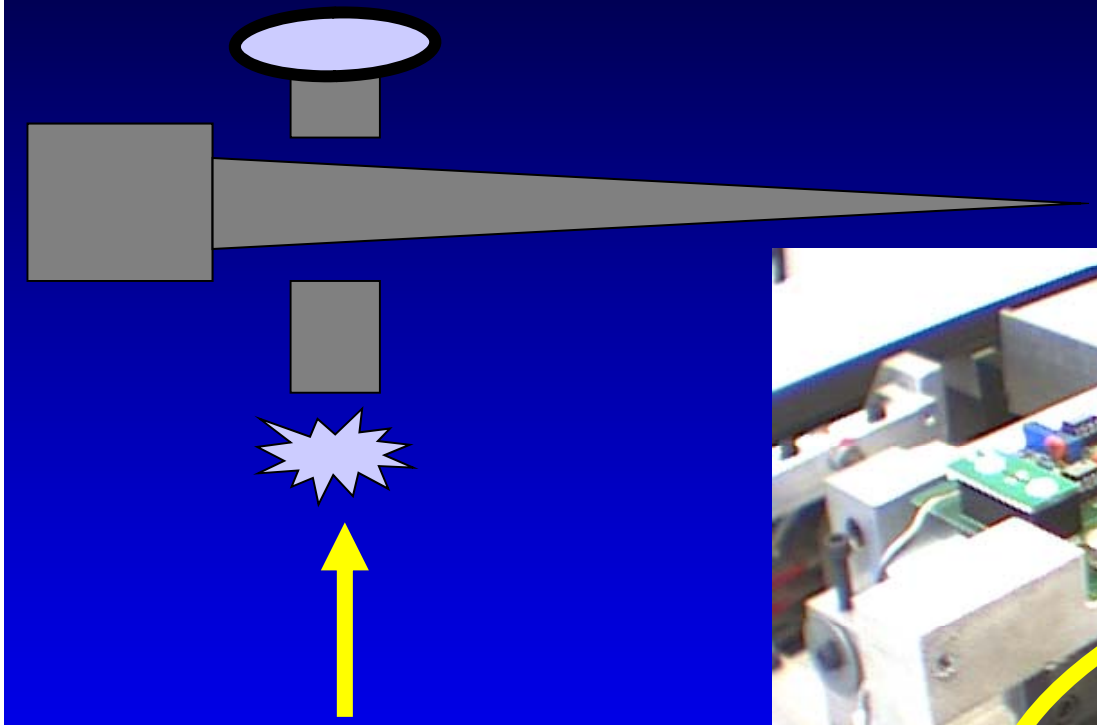


Mean and variability parameters

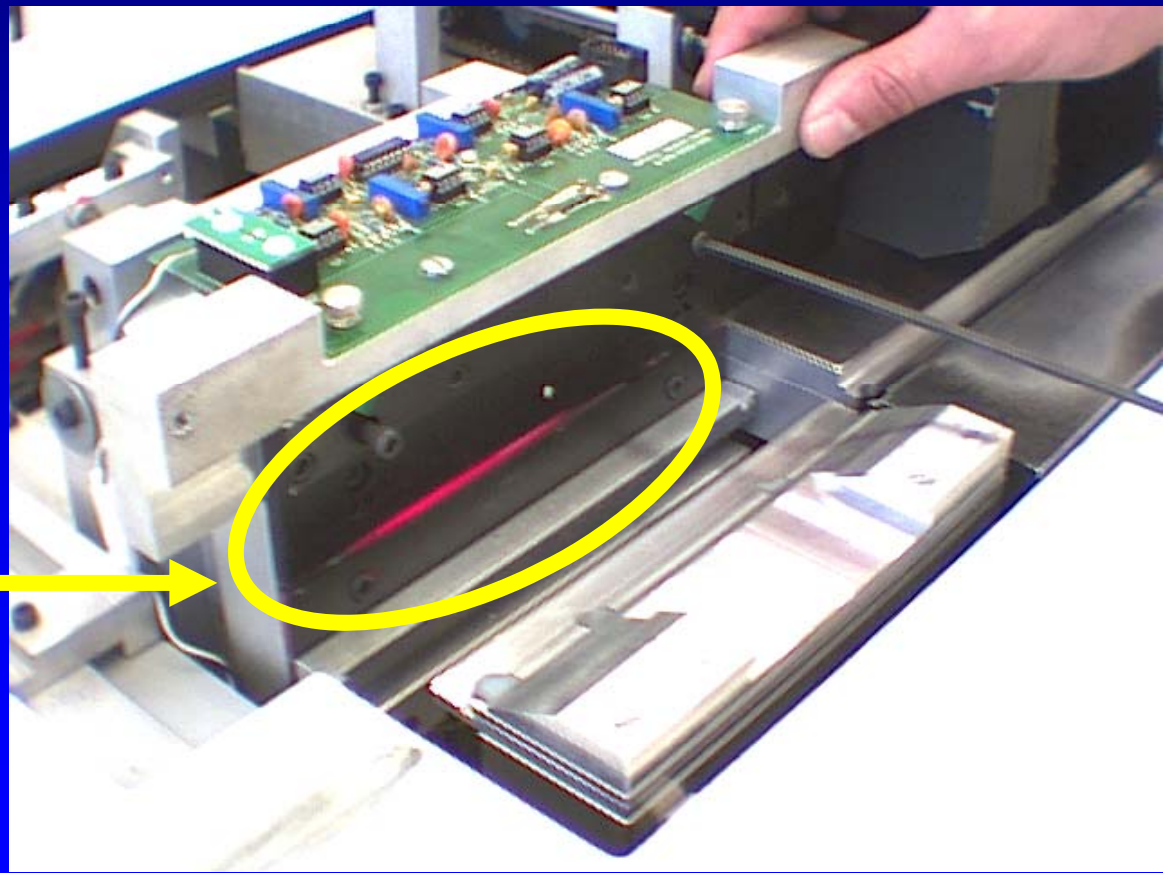
Fiber quality measurement
Length diagram (AFIS)



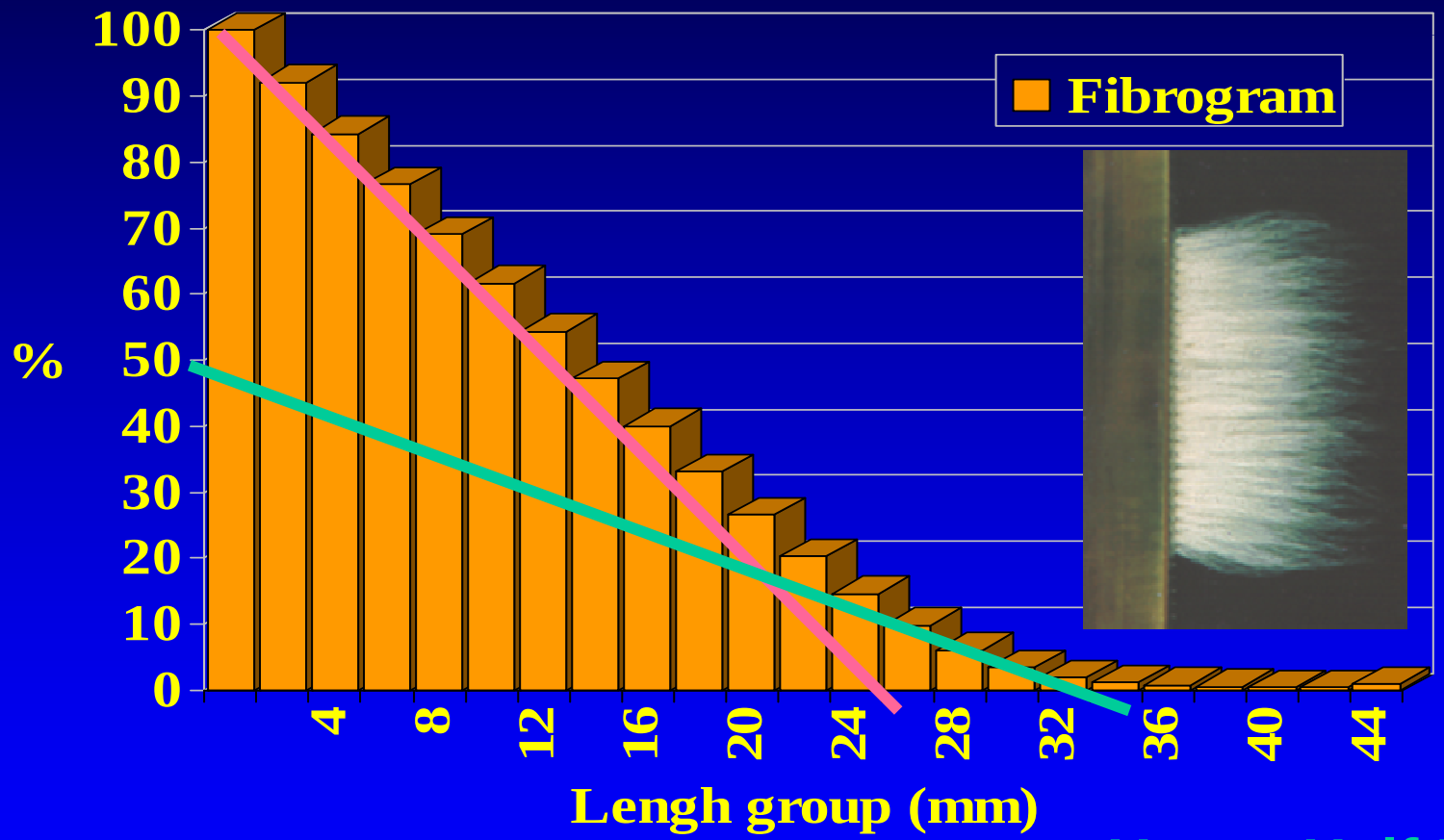
Fibre length
Part of the optical sensor



Capteur optique

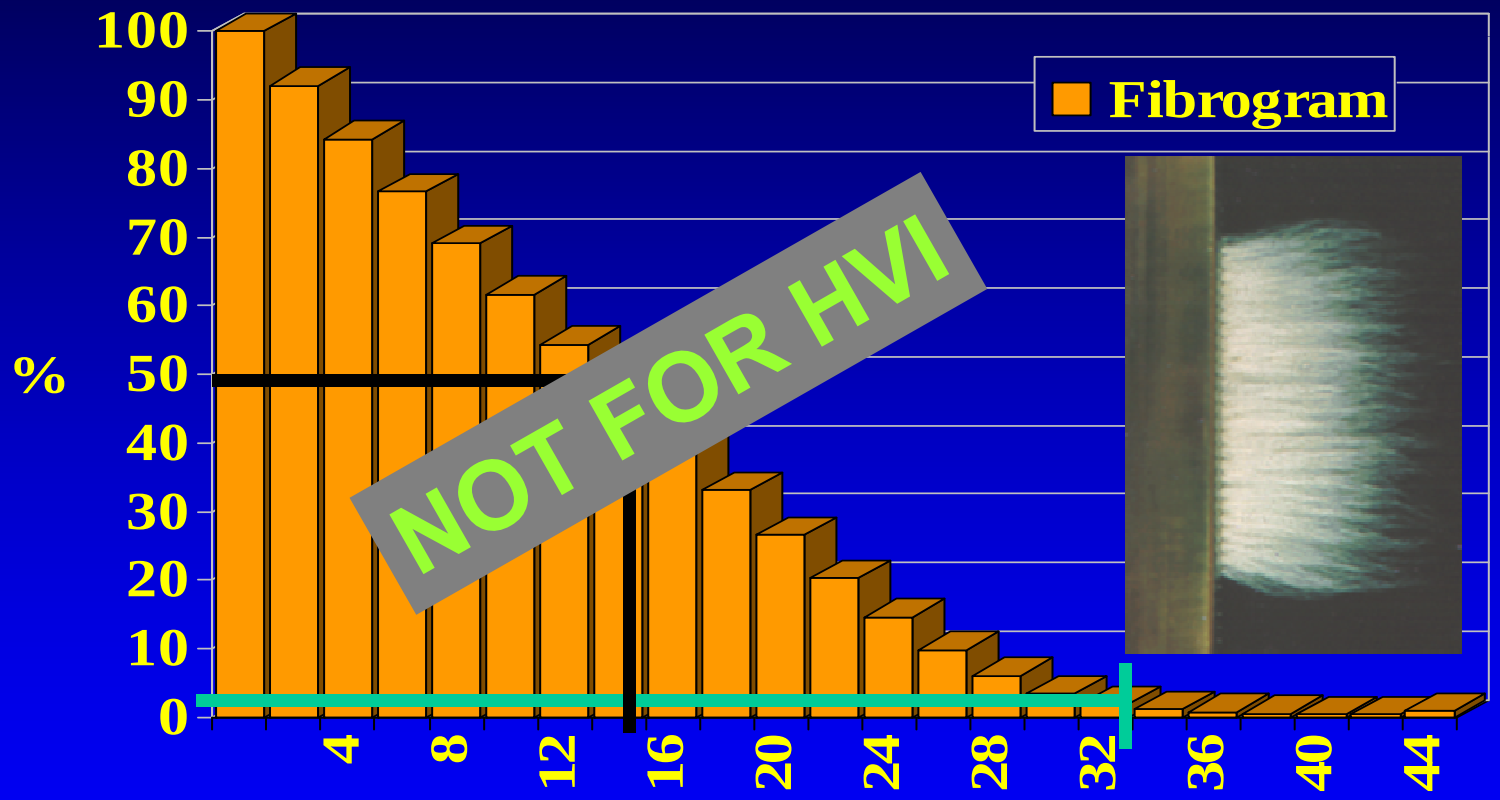


Fiber quality measurement
Length Fibrogram



$$\text{Uniformity Index \%} = \frac{ML \cdot 100}{UHML}$$

Fiber quality measurement
Length Fibrogram



SL 50 %

SL 2.5 %

$$UR\% = \frac{SL\ 50\ \%}{SL\ 2.5\ \%} \cdot 100$$

Fiber quality measurement
Length parameters

NOT FOR HVI

SL 2.5 ~ UHML ~ Pulling

22 – 40 mm

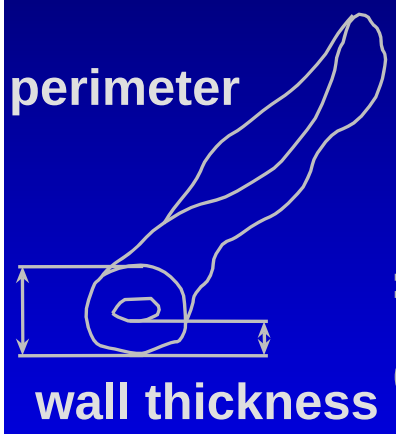
SL 50 % <> ML

10 – 18 mm 18 – 30 mm

UR % <> UI %

38 – 50 % 78 – 85 %

Fiber quality measurement

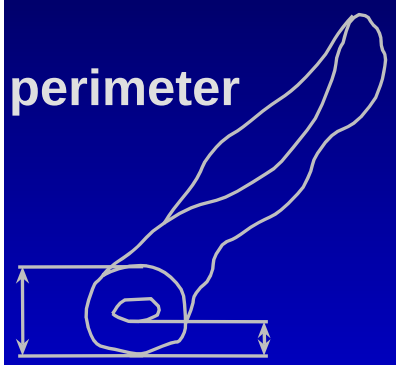


Why do we measure Fineness and Maturity ?

- Predict the number of fibers per yarn cross-section
- => yarn strength and eveness
- Chemical treatments and dye consumption
- Dye uptake ability

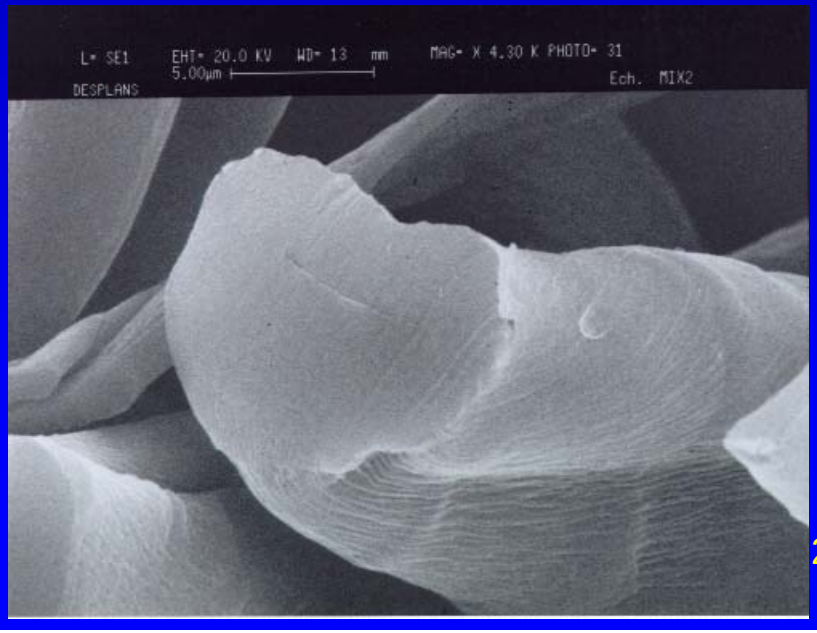
Fiber quality measurement

Manual :



using microscope on longitudinal fibers

using microscope on fibers sections

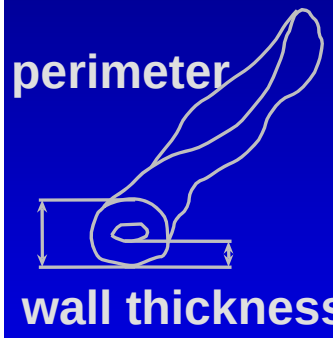


Fiber quality measurement

Manual :

<u>with classical instruments</u>

Fibronaire => Micronaire

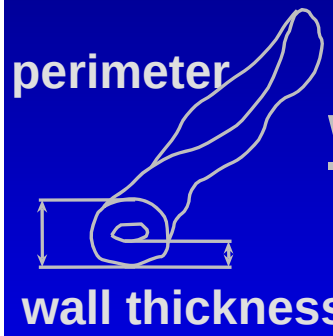


Fiber quality measurement

Manual :

<u>with classical instruments</u>

Fibronaire => Micronaire



<u>with Fineness Maturity Tester (FMT)</u>

IM, MR, PM%, H, HS

Fiber quality measurement

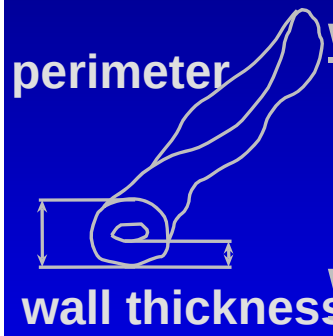
Manual :

<u>with classical instruments</u>

Fibronaire => Micronaire

<u>with Fineness Maturity Tester (FMT)</u>

IM, MR, PM%, H, HS



<u>with High Volume Instrument (HVI)</u>

Micronaire

Fiber quality measurement

Manual :

<u>with classical instruments</u>

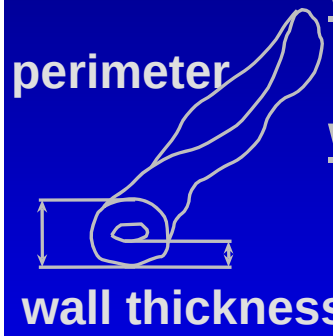
Fibronaire => Micronaire

<u>with Fineness Maturity Tester (FMT)</u>

IM, MR, PM%, H, HS

<u>with High Volume Instrument (HVI)</u>

Micronaire

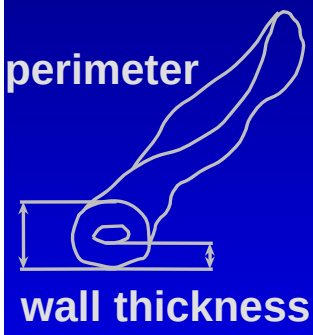


<u>with Advanced Fiber Information System (AFIS)</u>

Distribution of Diameter, Theta, MR, H

Fiber quality measurement

Recorded results:



IM : micronaire [2, 7]

MR : Maturity Ratio [0, 1.2]

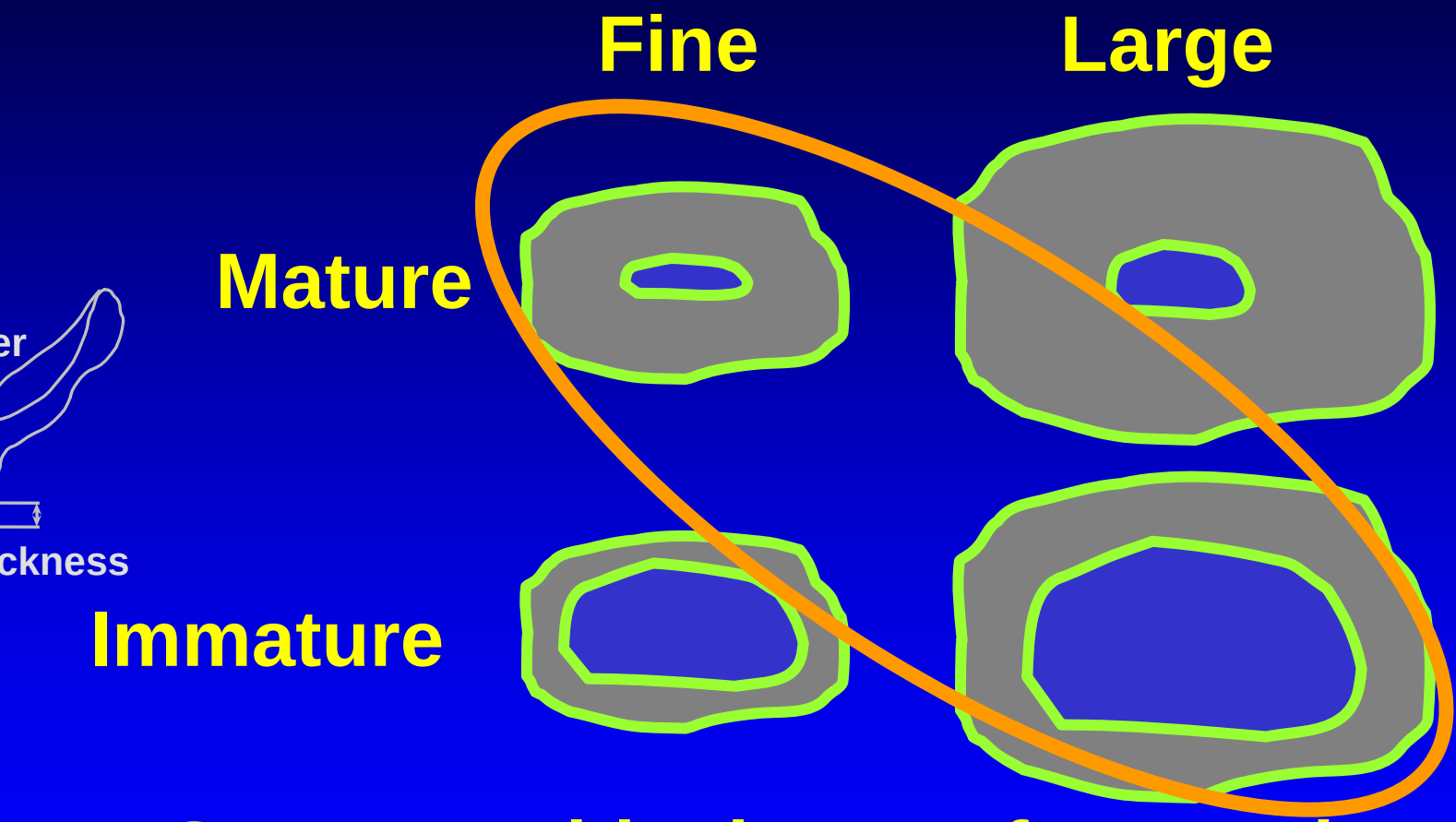
PM% : Percent Mature fibers [0, 100]

H : Linear Fineness (mtex) [120, 350]

Hs : Standard Fineness (mtex) [120, 400]

$$Hs = \frac{H}{MR}$$ (tex = grams/1000 m)

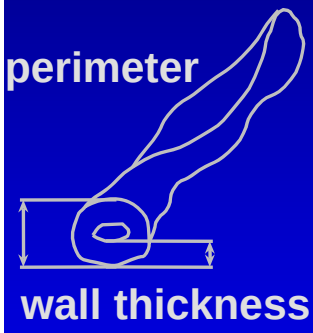
Micronaire, maturity and fineness

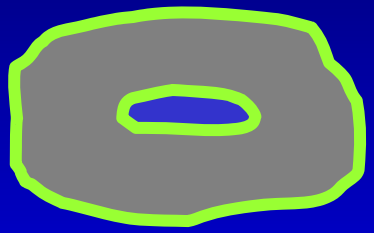


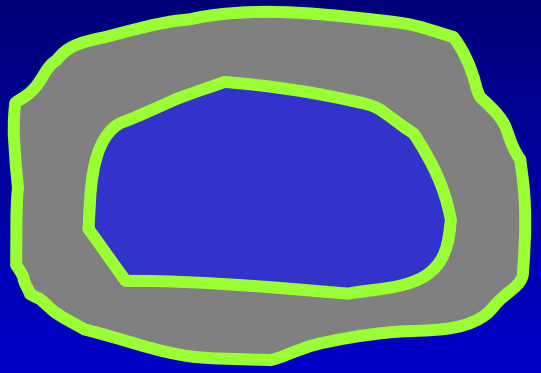
=> Some combinaisons of MR and H correspond to close IM for very different fibres

Micronaire, maturity and fineness

IM = 4.1



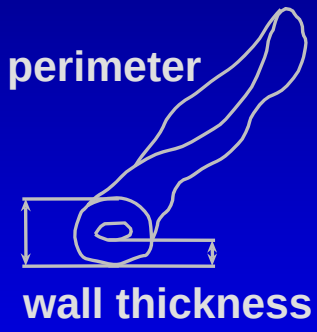




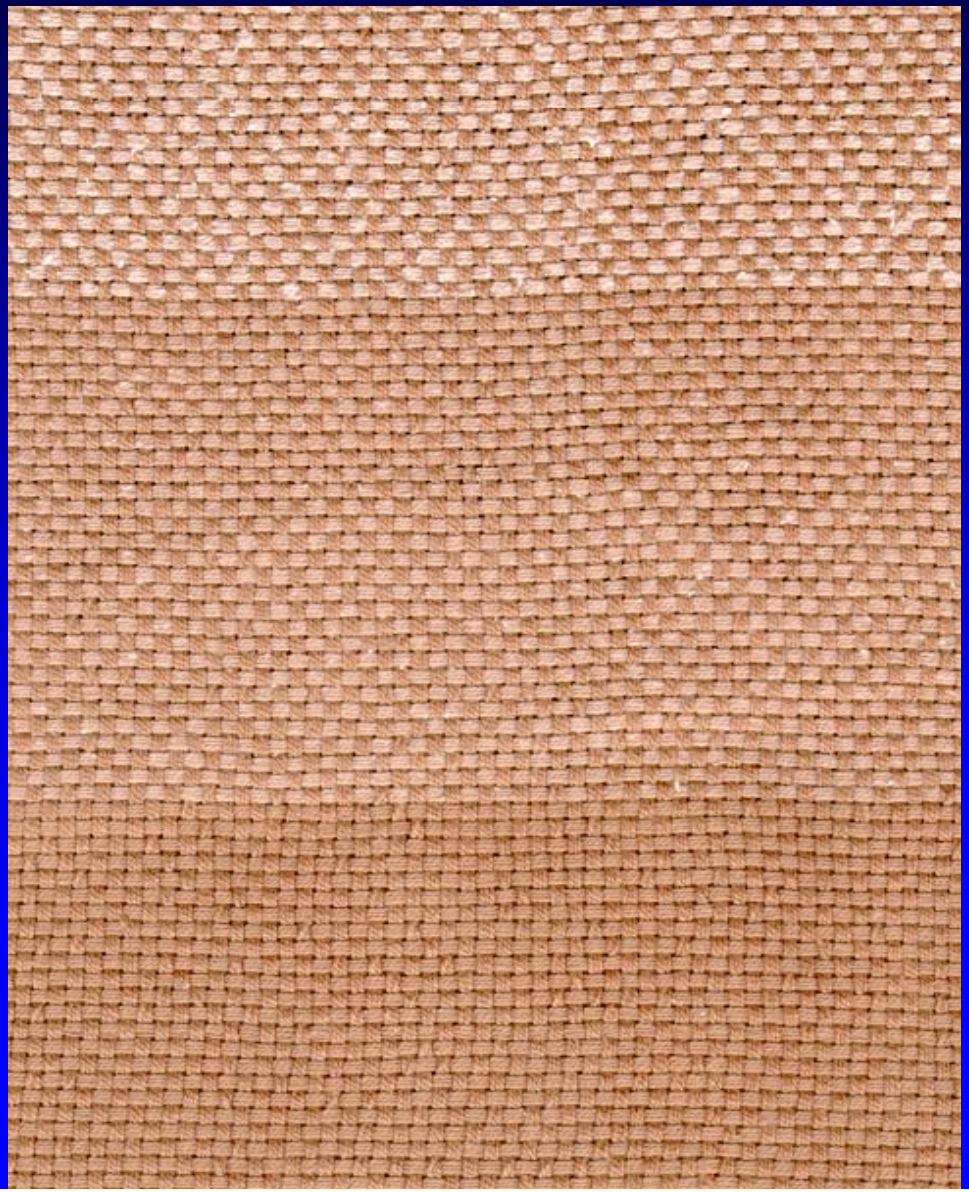
MR = 1.04
H = 150
Hs = 144

MR = 0.67
H = 220
Hs = 328

Fiber quality measurement



Warp, IM = 6.0



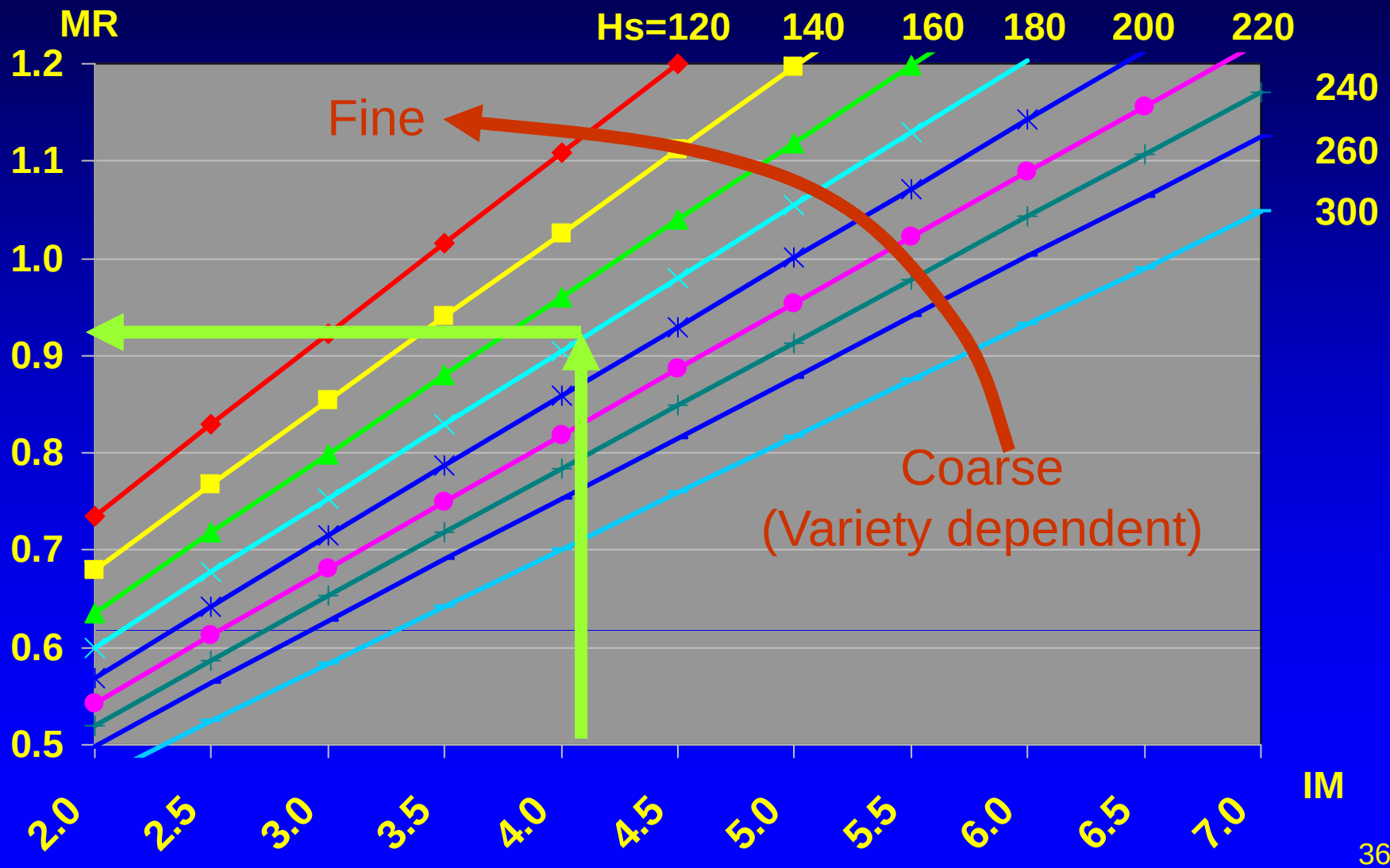
Weft

IM = 2.4

IM = 3.5

IM = 4.7

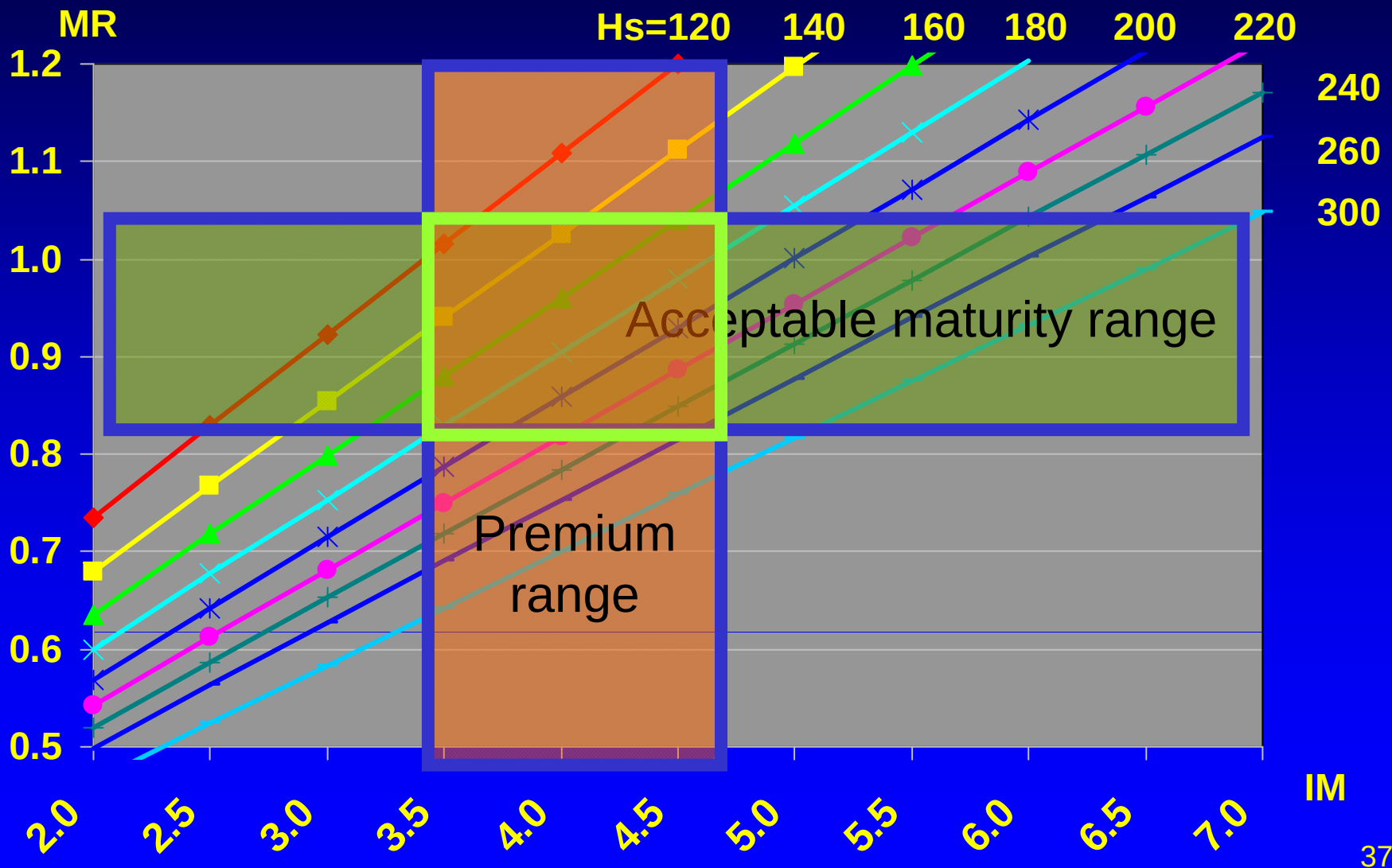
Relation between IM, MR and Hs



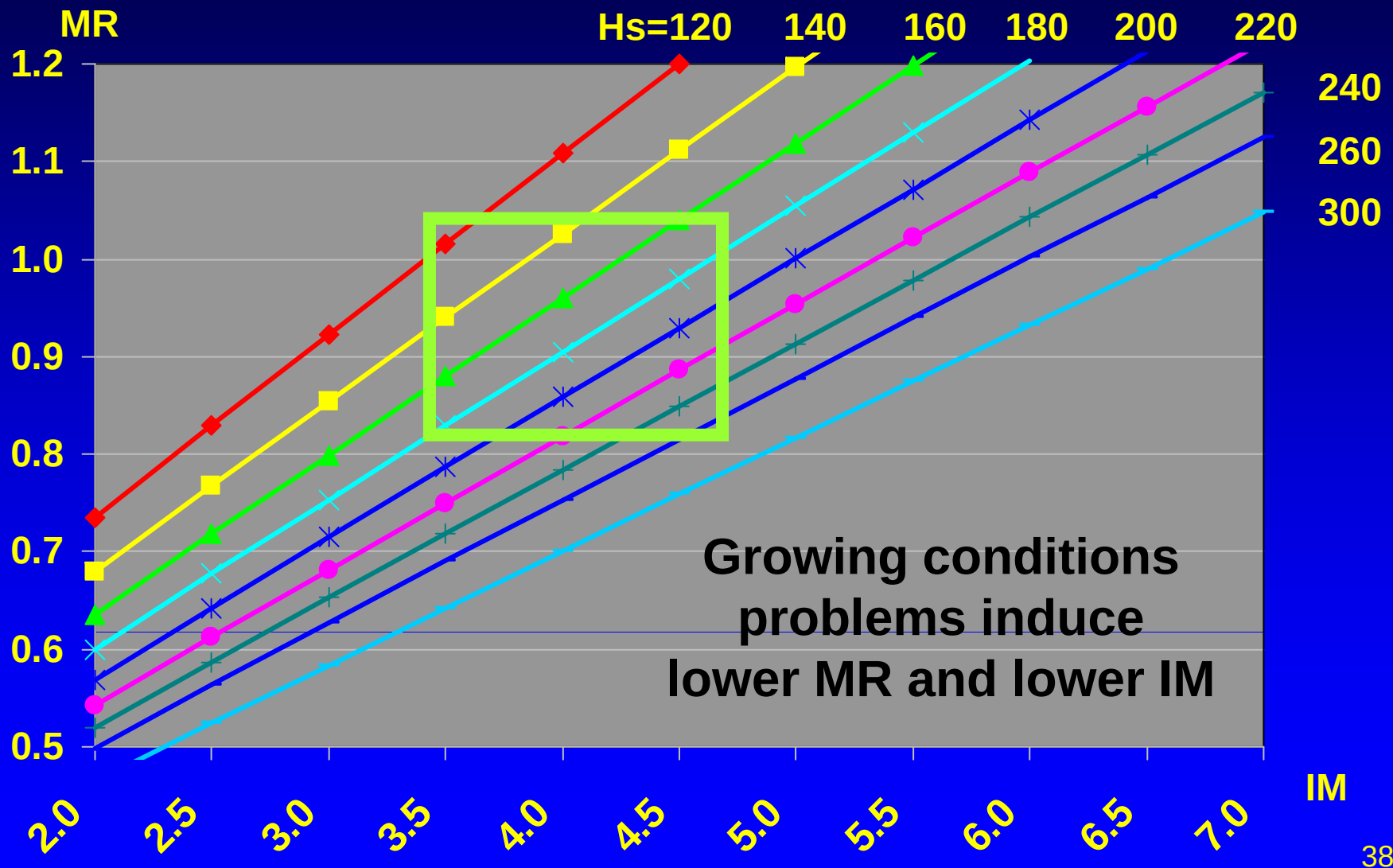
$MR^2 = (3.86 \times IM^2 + 18.16 \times IM + 13) / Hs$

$PM = (MR - 0.2) \times (1.565 - 0.471 \times MR) \times 100$

Relation between IM, MR and Hs

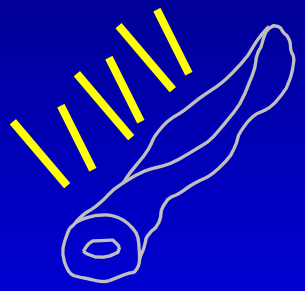


Relation between IM, MR and Hs



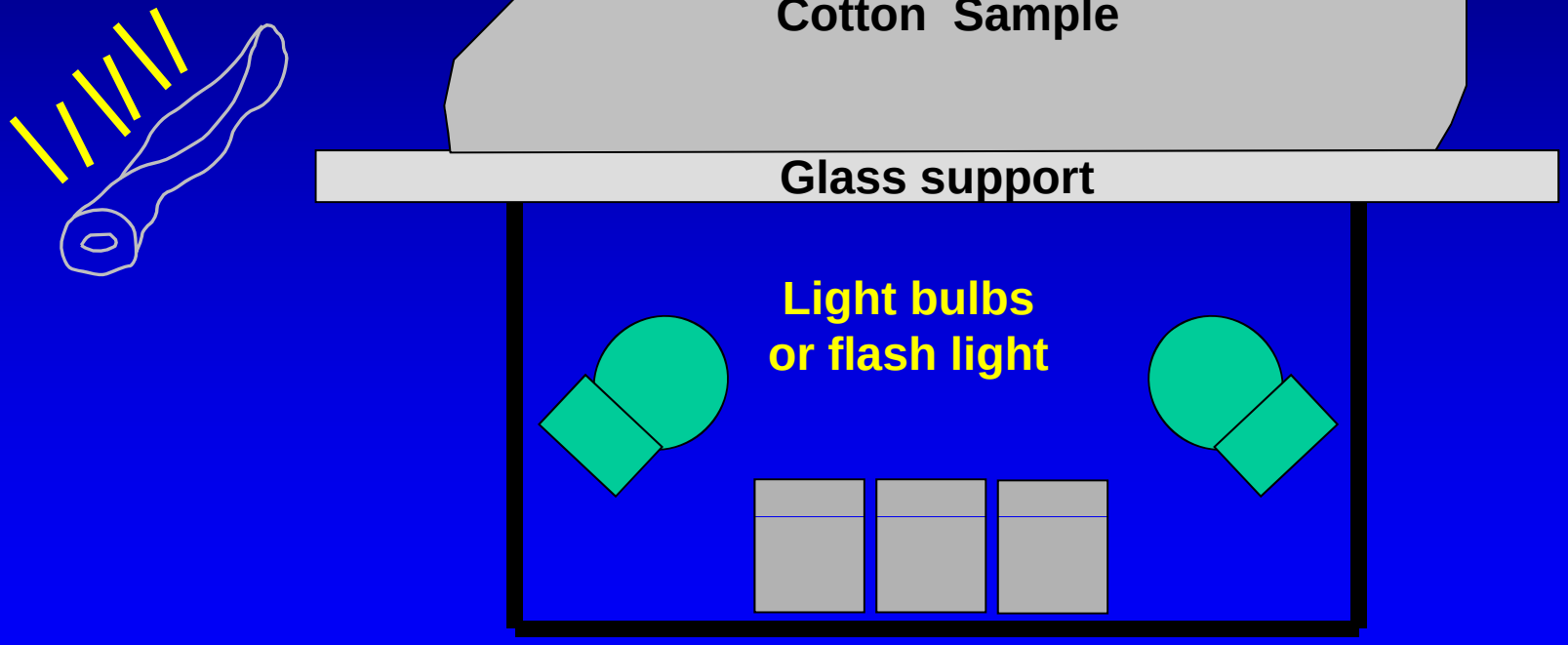
Fiber quality measurement

Why do we measure color and trash ?



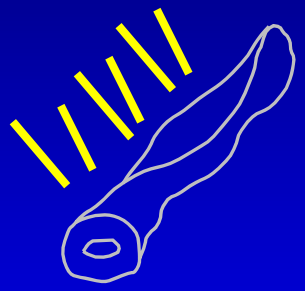
- To identify bales having homogeneous characteristics and group them per lot
- To avoid variations in color in raw and dyed fabrics
- To limit wastes during processing

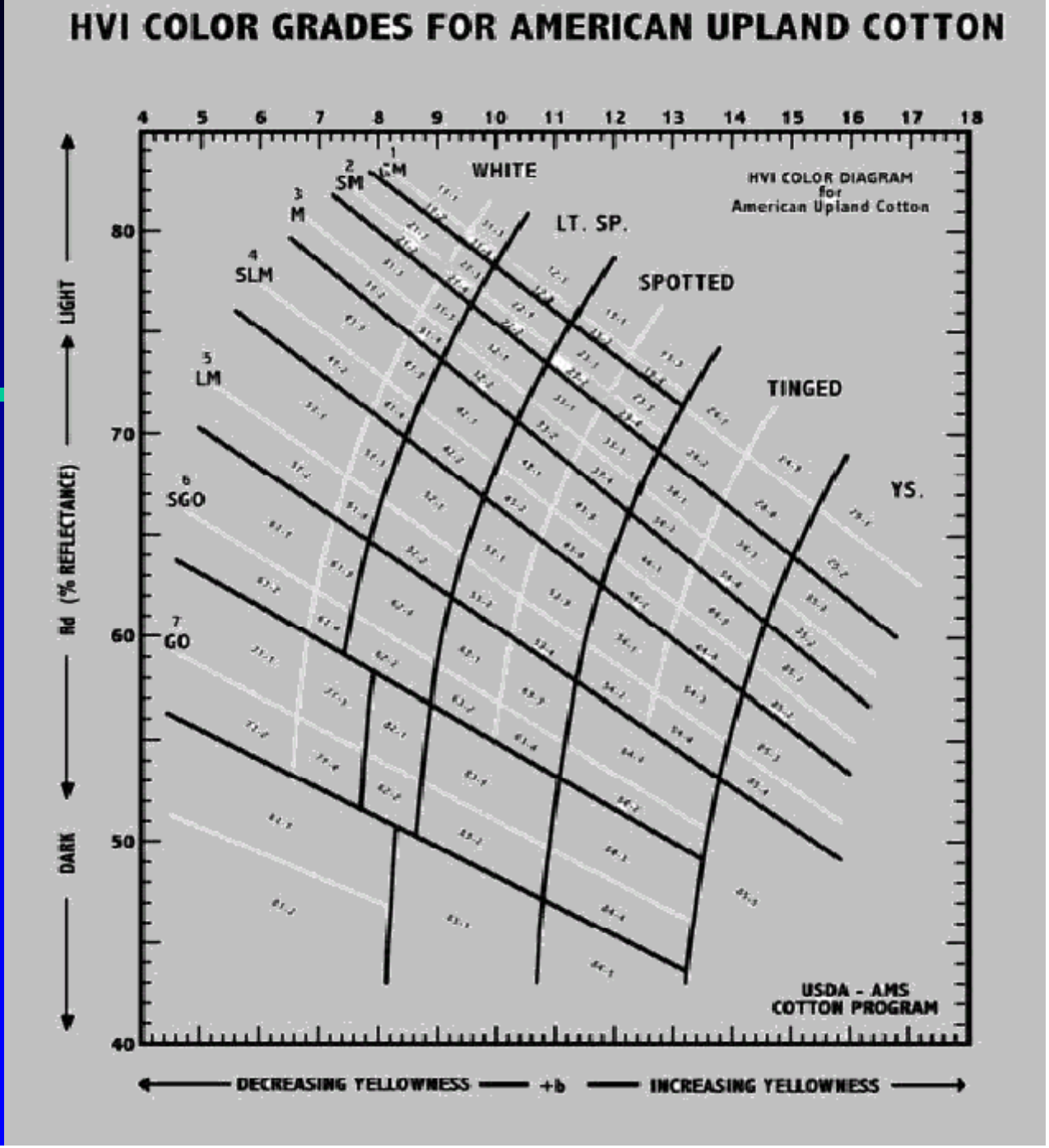
Fiber quality measurement



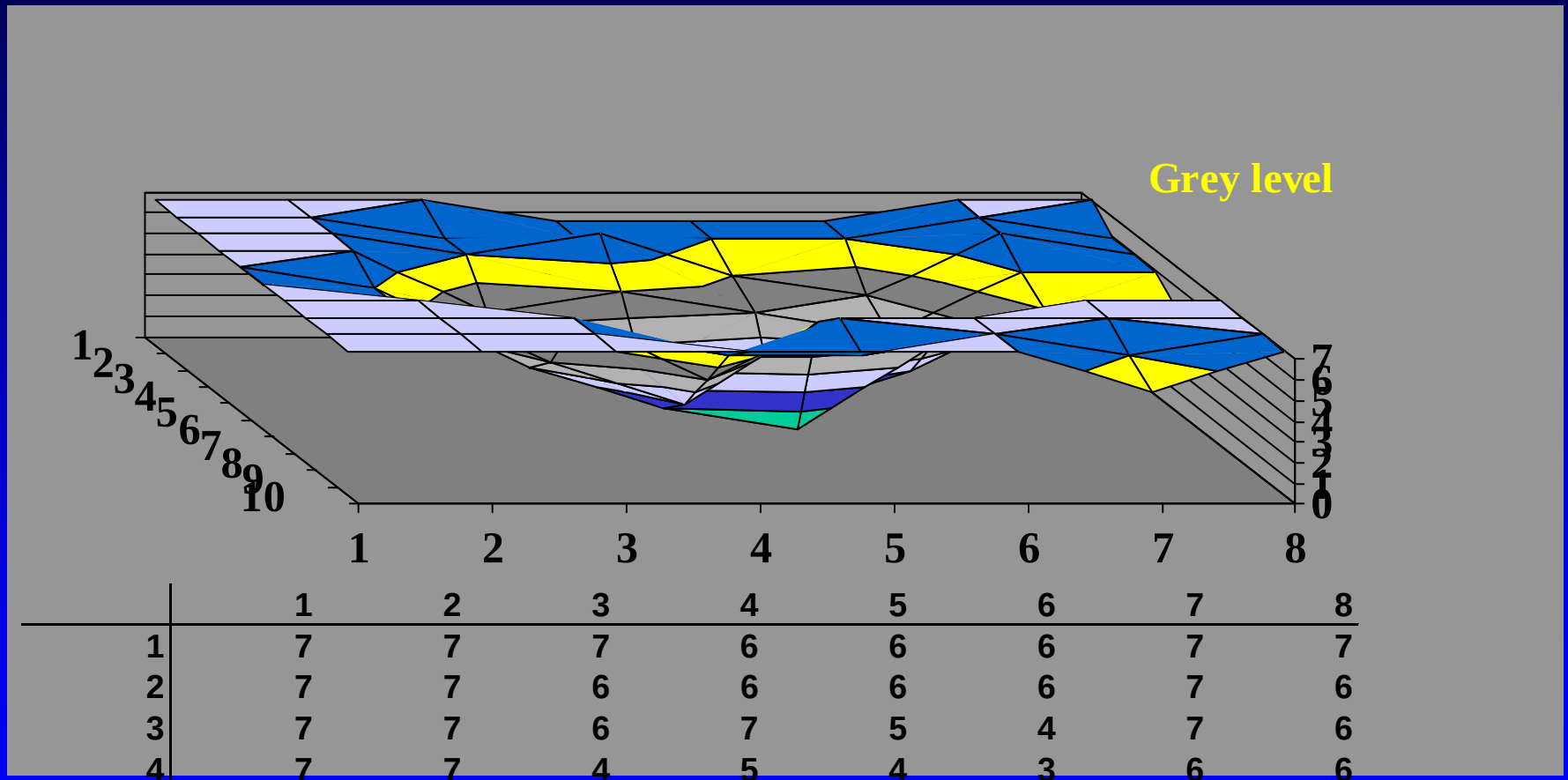
Reflectance Rd % **Yellowness + b** **Image analysis …**

Fiber quality measurement





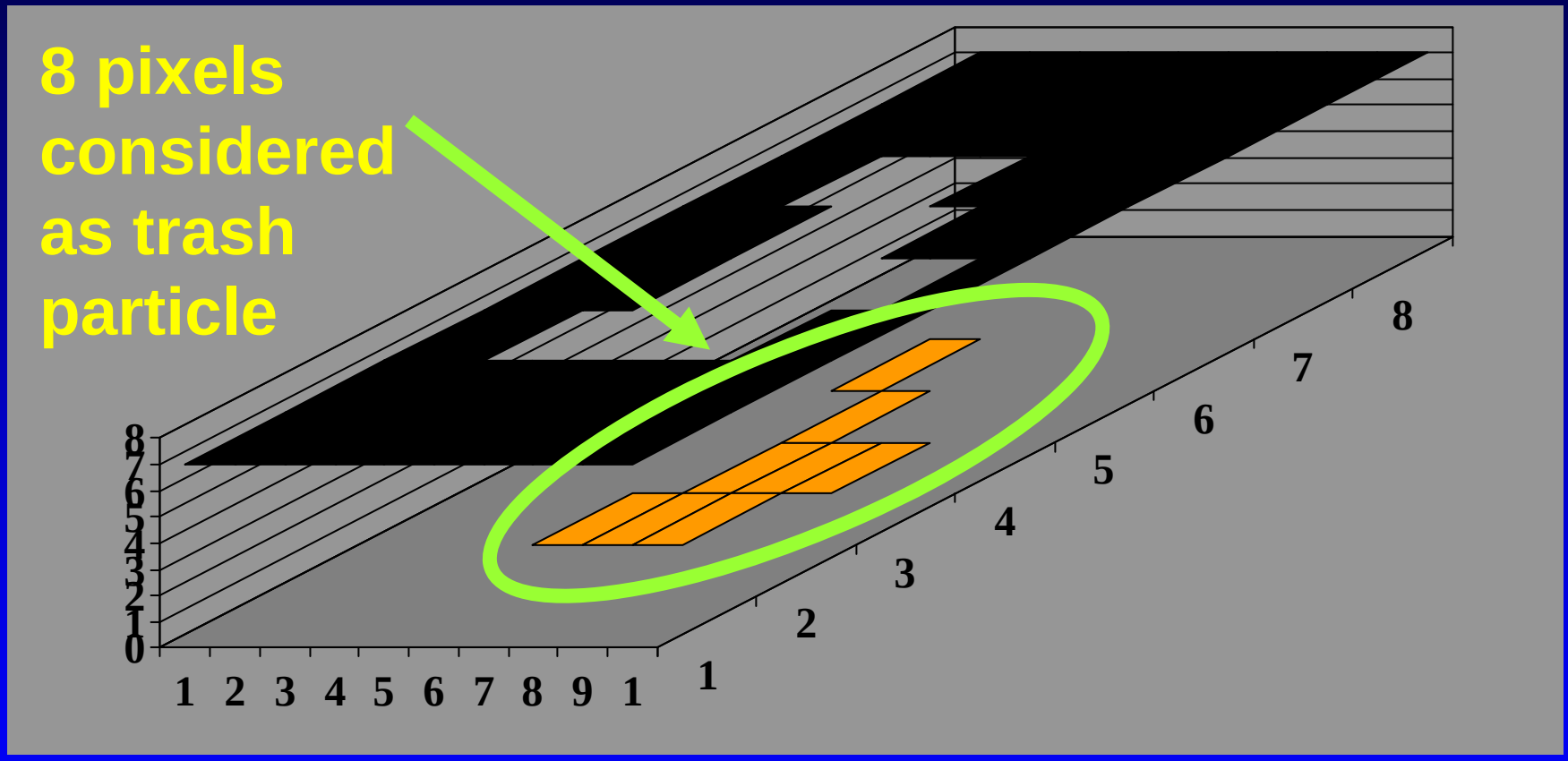
Fiber quality measurement
Trashmeter image



	1	2	3	4	5	6	7	8
1	7	7	7	6	6	6	7	7
2	7	7	6	6	6	6	7	6
3	7	7	6	7	5	4	7	6
4	7	7	4	5	4	3	6	6
5	7	6	3	2	0	2	5	5
6	7	6	3	1	0	4	5	5
7	7	7	4	2	6	6	7	7

Binarisation and threshold applied …

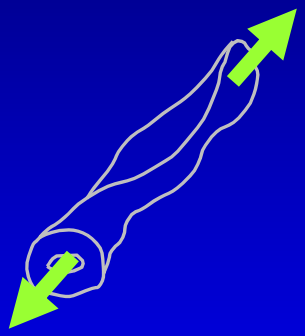
Fiber quality measurement
Trashmeter image



Trash count, Trash area, Leaf, Leaf grade

Fiber quality measurement

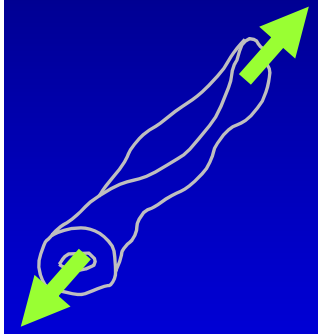
Why do we measure strength ?



- To define what product can be made from these fibers
- To define a commercial price
- To predict yarn strength

Fiber quality measurement

Manual :



with classical instruments

Stelometer : T1 (cN/tex) and elongation E1 (%)

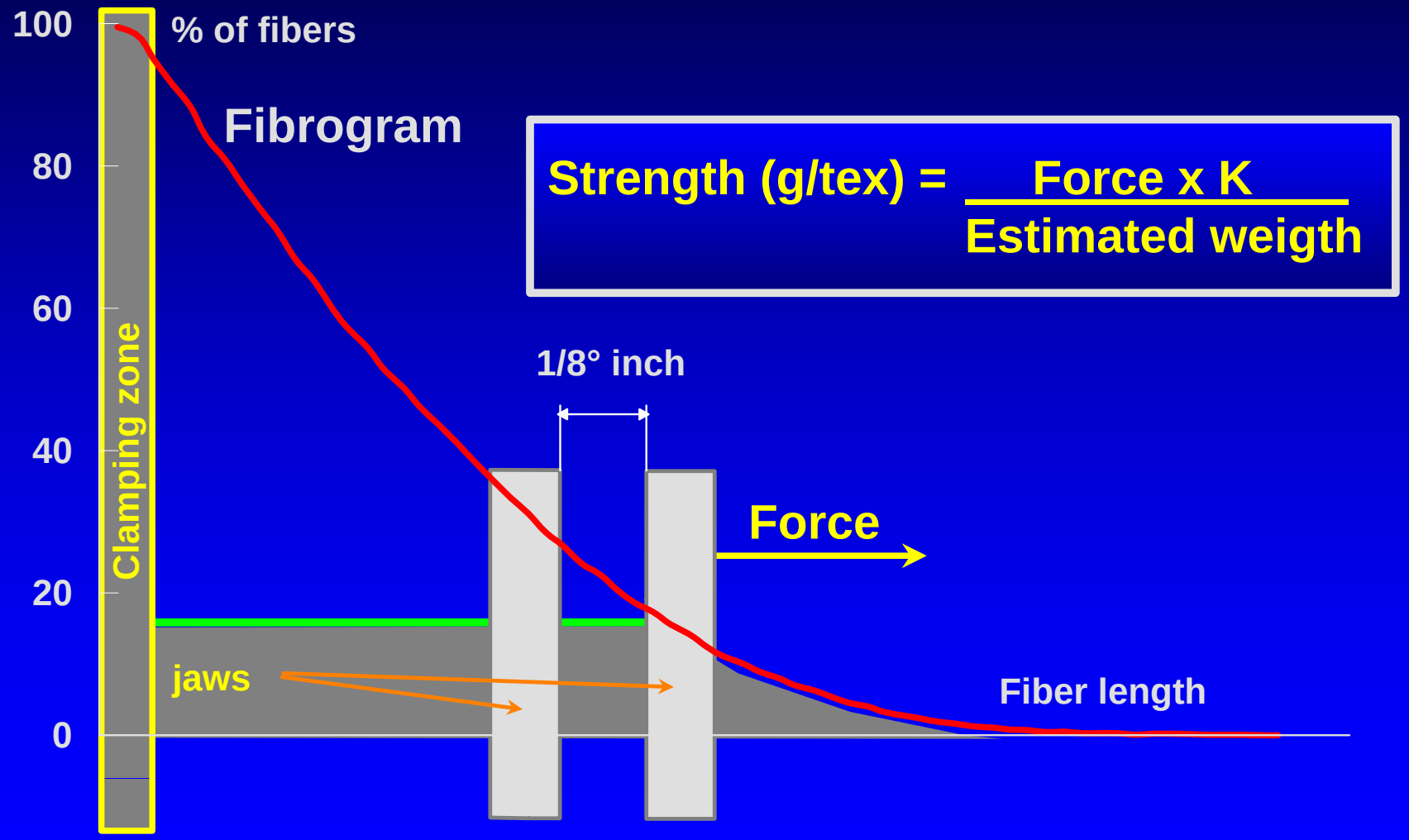
with High Volume Instrument (HVI)

Strength (cN/tex) and elongation Elong (%)

with devices measuring individual fibers

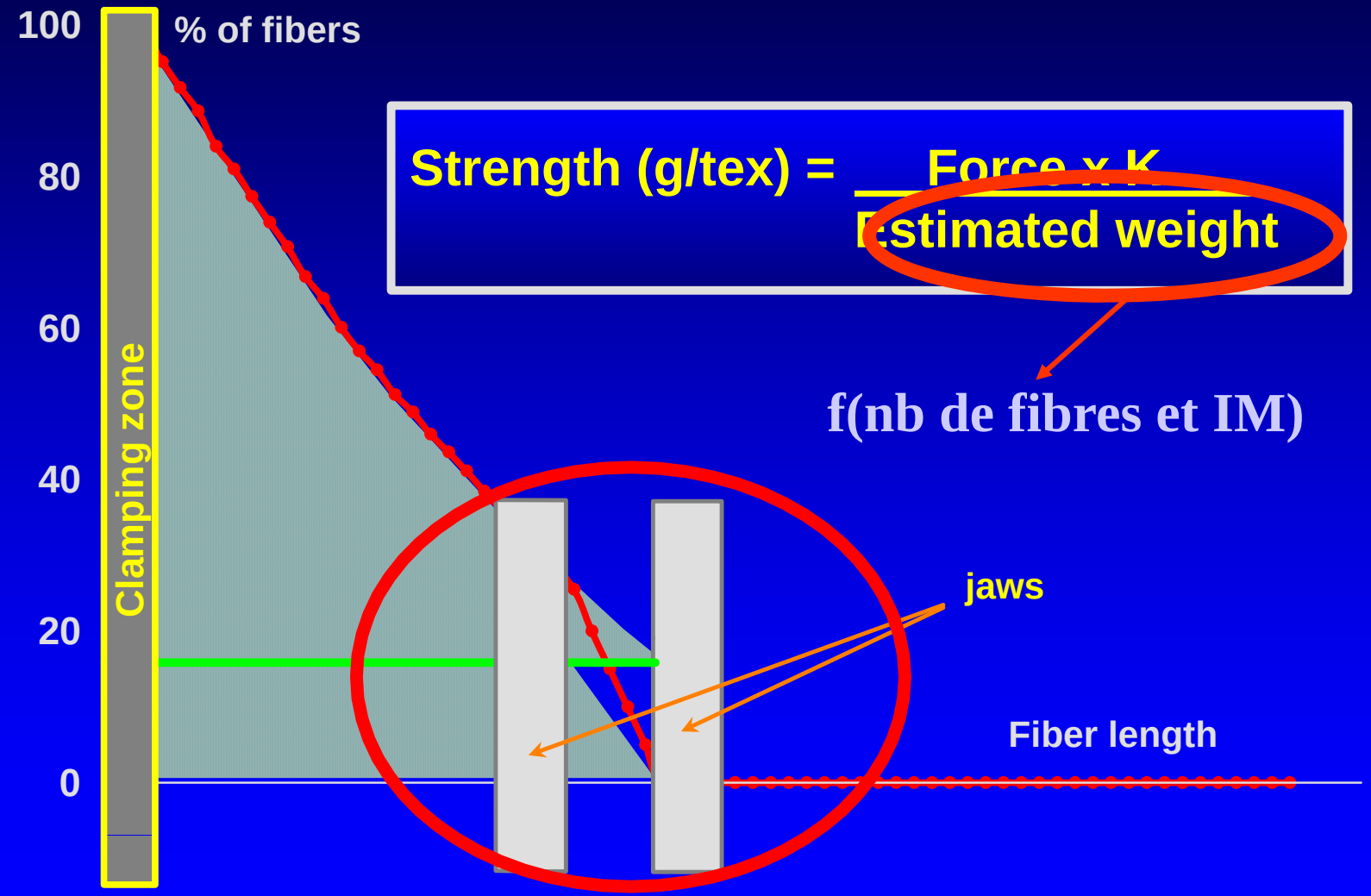
Breaking force and elongation

Fibrogram curve



$$\text{Strength (g/tex)} = \frac{\text{Force x K}}{\text{Estimated weigth}}$$

Fibrogram curve after a break



Caractérisation de la fibre

Les principales caractéristiques de fibre peuvent être établies soit manuellement, soit sur appareils classiques ou soit sur chaînes HVI.

Seules les chaînes HVI :

- **permettent des mesures instrumentales, automatisées, rapides et intégrées des critères commerciaux,**
- **et autorisent un classement balle à balle sur l ’ensemble de ces critères**

Fibre quality per spinning method

Rank	Ring spinning	Open end	Air-jet
1	Length	Strength	Length
2	Strength	Fineness	Trash
3	Fineness	Length	Fineness
4	Trash	Trash	Strength

Deussen, 1992

Fiber quality measurement

Length

Micronaire

Length uniformity

Color
Trash content

Strength
and more

Example of ITC

(This display does not constitute any type of recommendation for this equipment, picture from an advertisement from Uster Technologies)

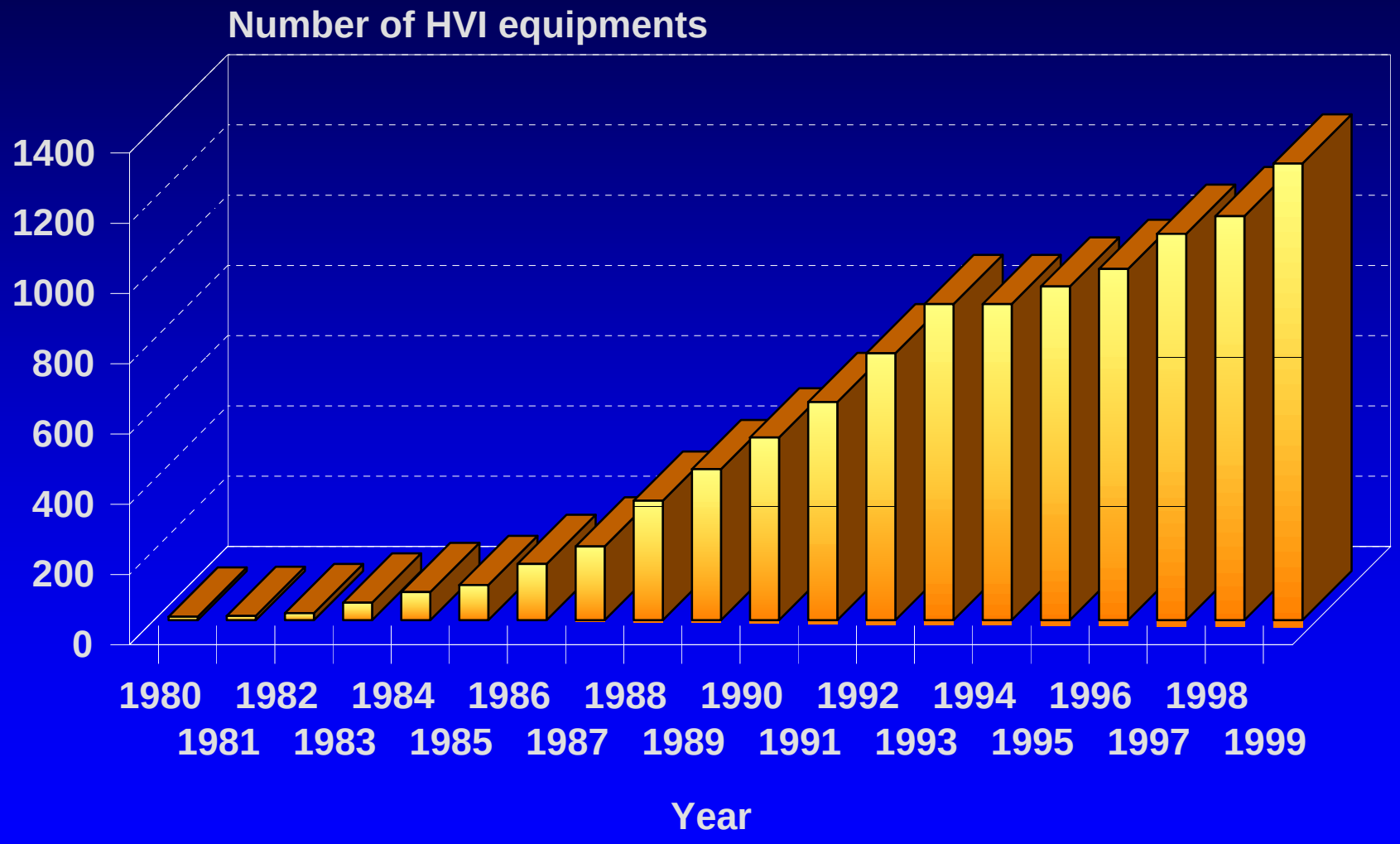
Example of HVI classification in Dumas (AK)

Fiber quality measurement

Actual major manufacturers of so-call HVI equipments (alphabetic order)

- Lintronics (Israel)
- Premier (India)
- Schaffner Technologies (USA)
- Zellweger Uster (USA)

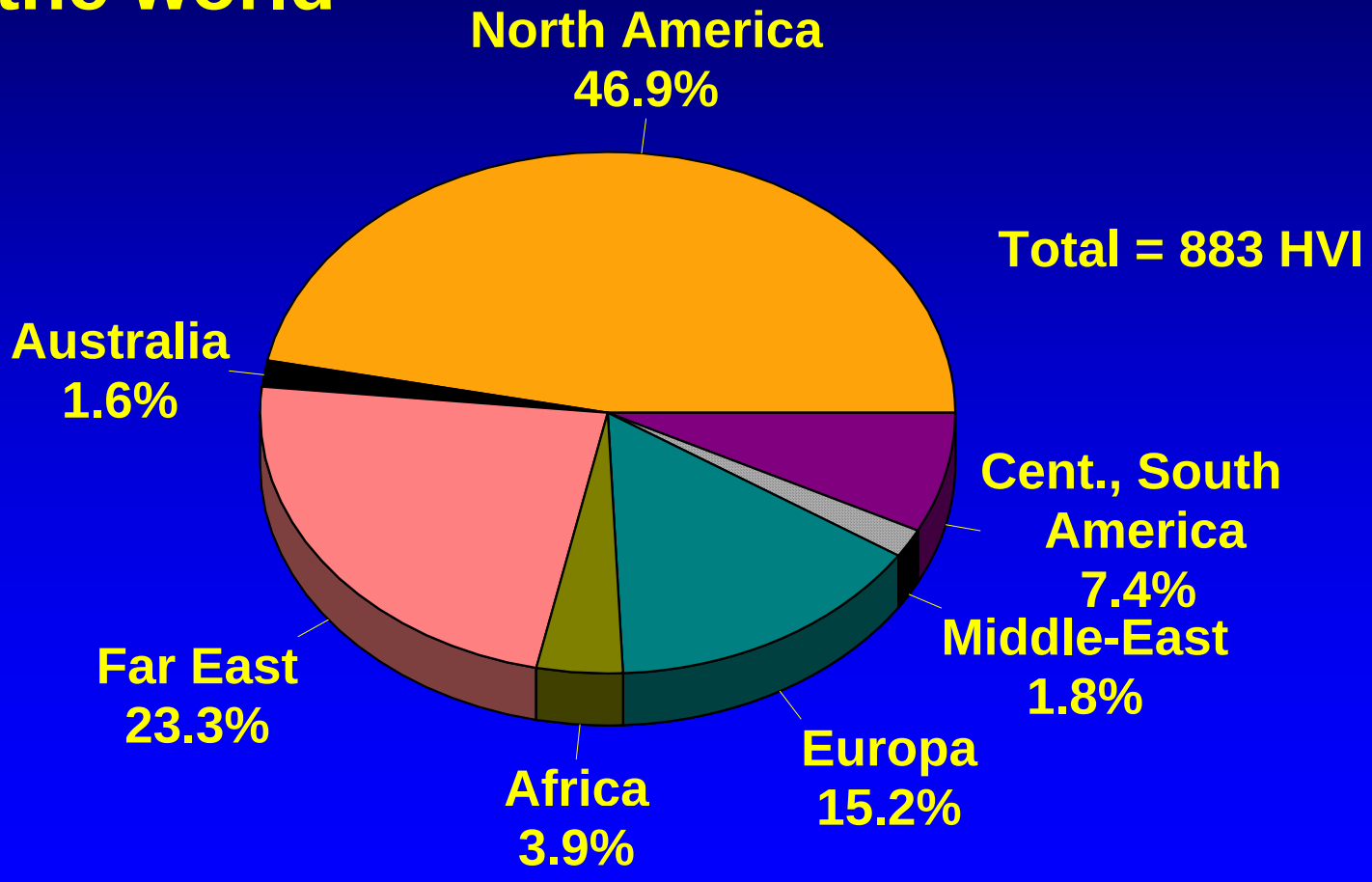
Fiber quality measurement



From Hunter, 2000

Fiber quality measurement

High Volume Instrument (HVI) in the world



Source : HUNTER L., ITMF Committee, Brème, Mars 1994.

Plan of presentation

- Introduction
- Different ways of fibers characterization
- **A point about the standardization process**
- **How does work an HVI**
- **An example of relation between fiber and yarn quality**
- **Conclusions**

Normalization steps

1923
Universal Standards :
Grade, Pulling ;
Transactions .

1940-1950
International Calibration
Cotton Standards (ICCS) ;
Research + Transactions.

1986
HVI Calibration Cotton ;
Transactions, USA.

1995/1998
- ICCS restricted for
research ;
- HVI Calibration Cotton
Transactions, world.

Time

Based on so-call ’reference methods’

Expected precision for international market

	Confidence interval
IM	(+/-) 0.1 unit
Length	(+/-) 0.02 inch
	(+/-) 0.51 mm
Length uniformity	(+/-) 1.5 %
Strength	(+/-) 1.5 cN/tex
Rd %	(+/-) 1 %
+b	(+/-) 0.5
Trash	(+/-) 0.1 %

From Sasser, 1992.

Reference cotton use in the world: 1991

Who	No HVI	Consumption			
		HVICC kg	Ratio kg/HVI	ICCS kg	Ratio kg/HVI
USDA	212	19214	91	3023	14.2
USA except USDA	91	828	9	49	0.5
Outside USA	318	192	0.6	1.8	0.004
Total	621				

Reference cotton use in the world: 1994

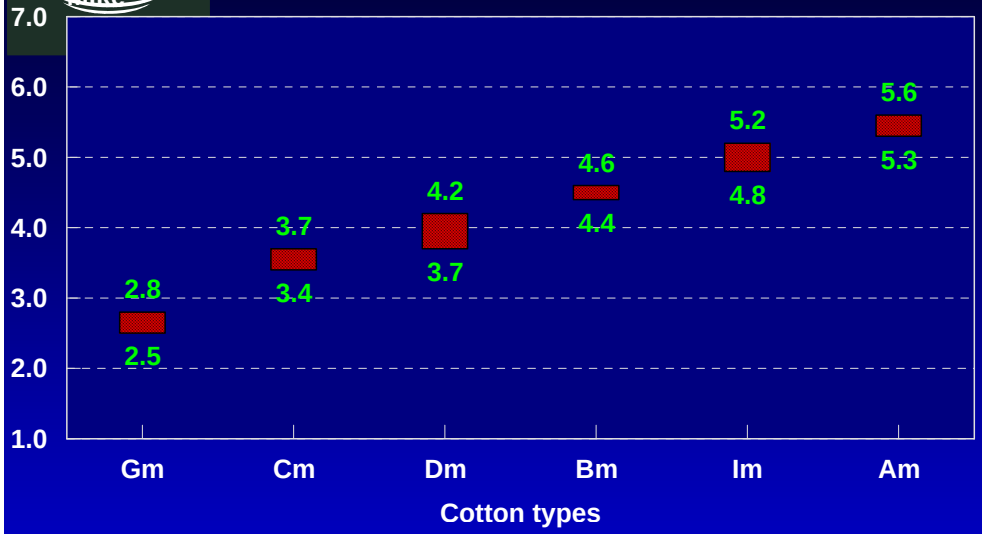
Who	No HVI	Consumption			
		HVICC kg	Ratio kg/HVI	ICCS kg	Ratio kg/HVI
USDA	x	14145	?	6803	?
		-21%		+125%	
USA except USDA	x	766	?	127	?
		- 7%		+159%	
Outside USA	x	245	?	42	?
		+27%		+2200%	
Total	883				
	+42%				

Existing reference cottons after 1998

ICCS	ICCS Mike only	HVICC
* Stelometer	HVI	HVI
* Carded cotton	Raw cotton	Raw cotton
* 3 types	6 types	2* 2 types
* Measurement of T1 E1 (1 type with SL%)	Mike	Length (UHM) UI% Strength

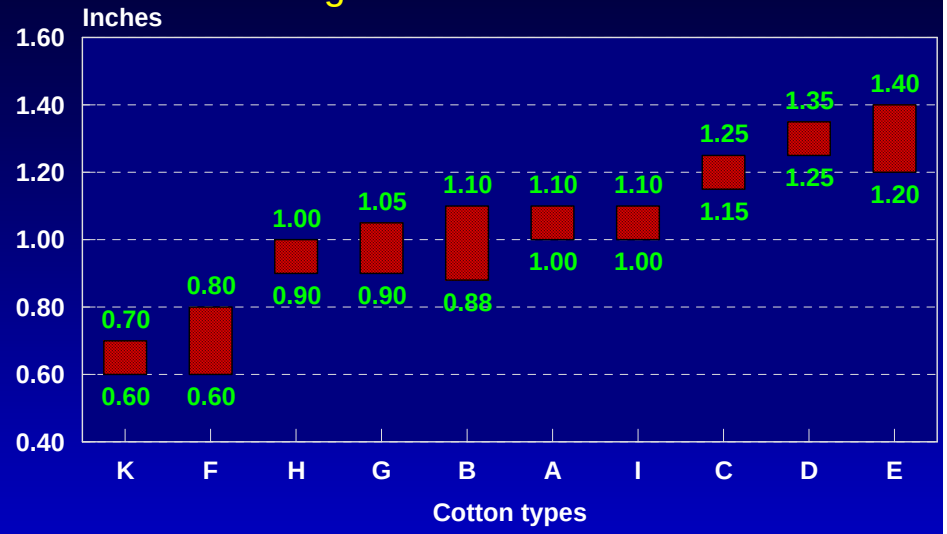
6 - International normalisation of the measurements

ICCS Mike only standards

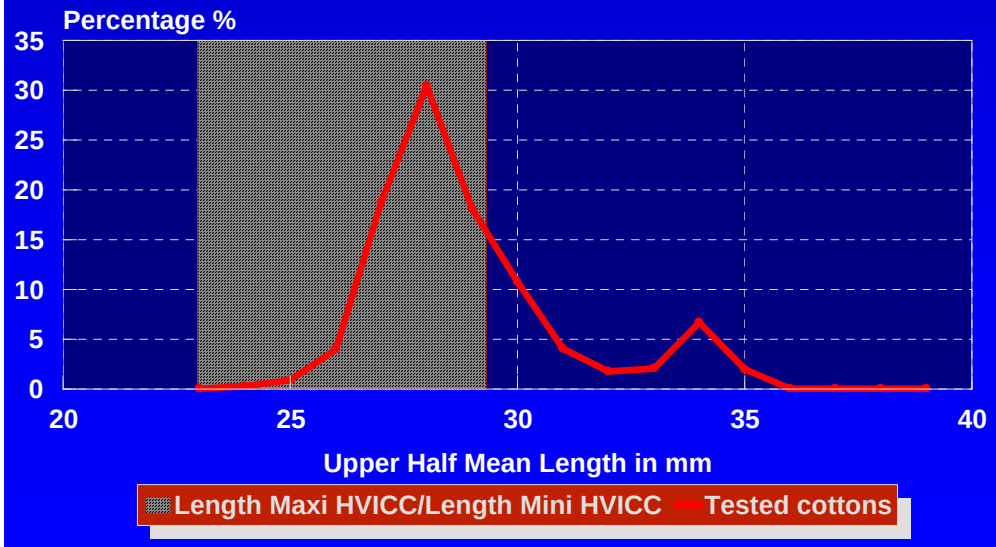


6 - International normalisation of the measurements

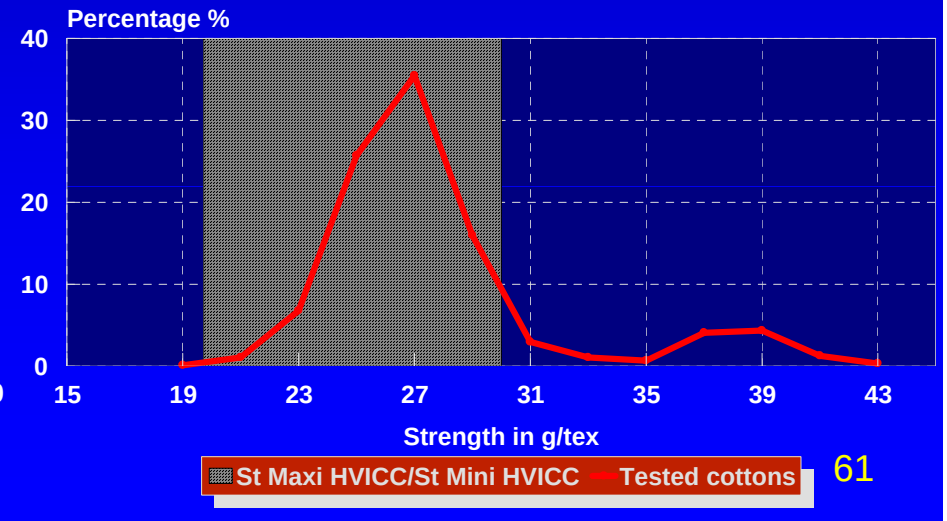
Length of ICCS standards



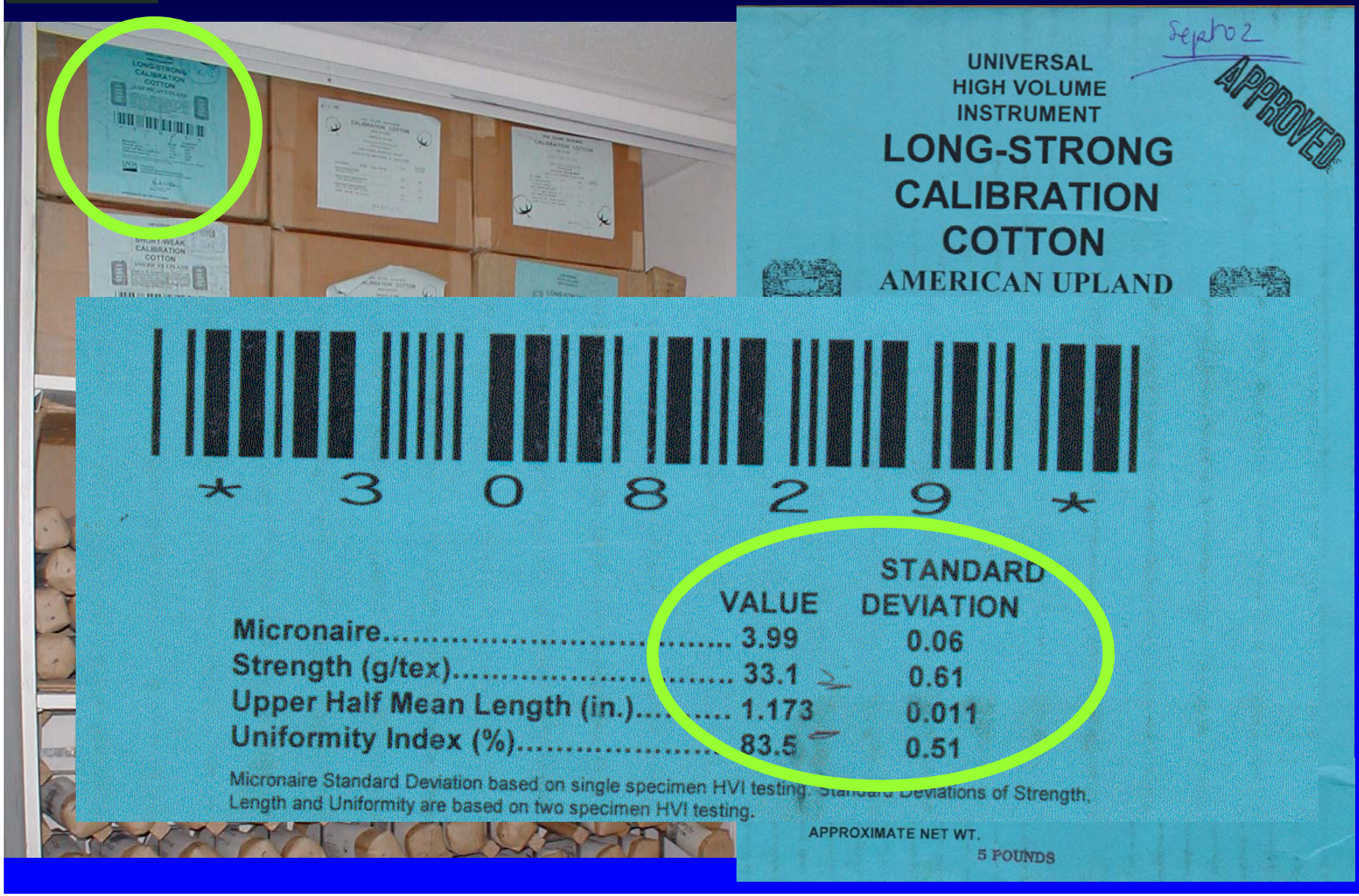
Upper Half Mean Length Histogram
2356 Cottons from different origins



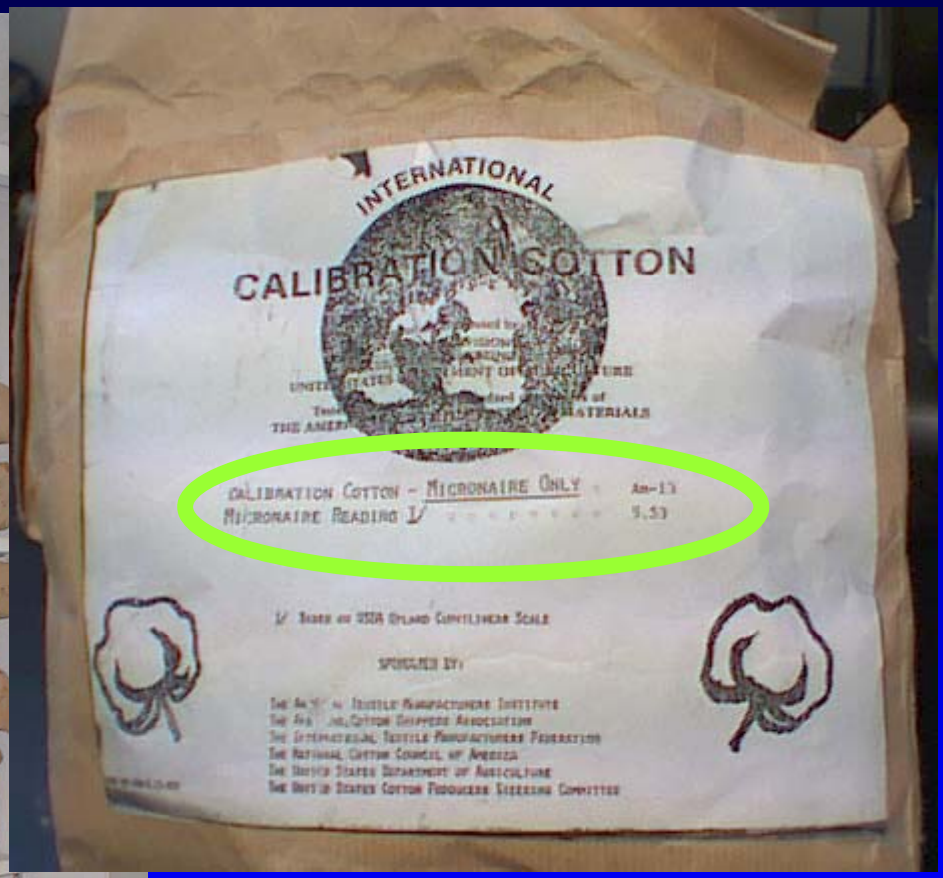
Strength Histogram
2356 Cottons from different origins



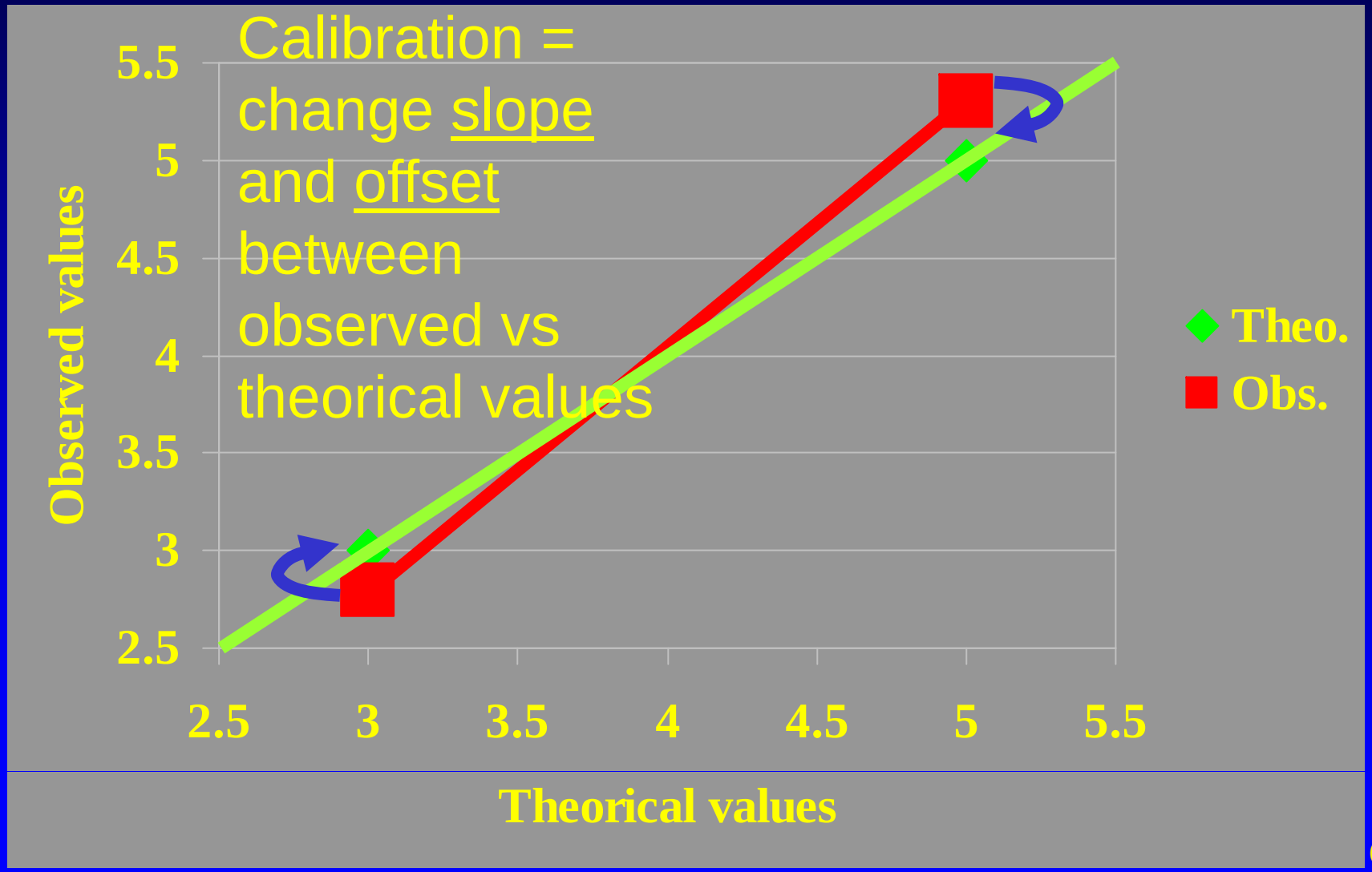
Existing reference cottons after 1998



Existing reference cottons after 1998



HVI modules calibration : IM



About reference values establishement

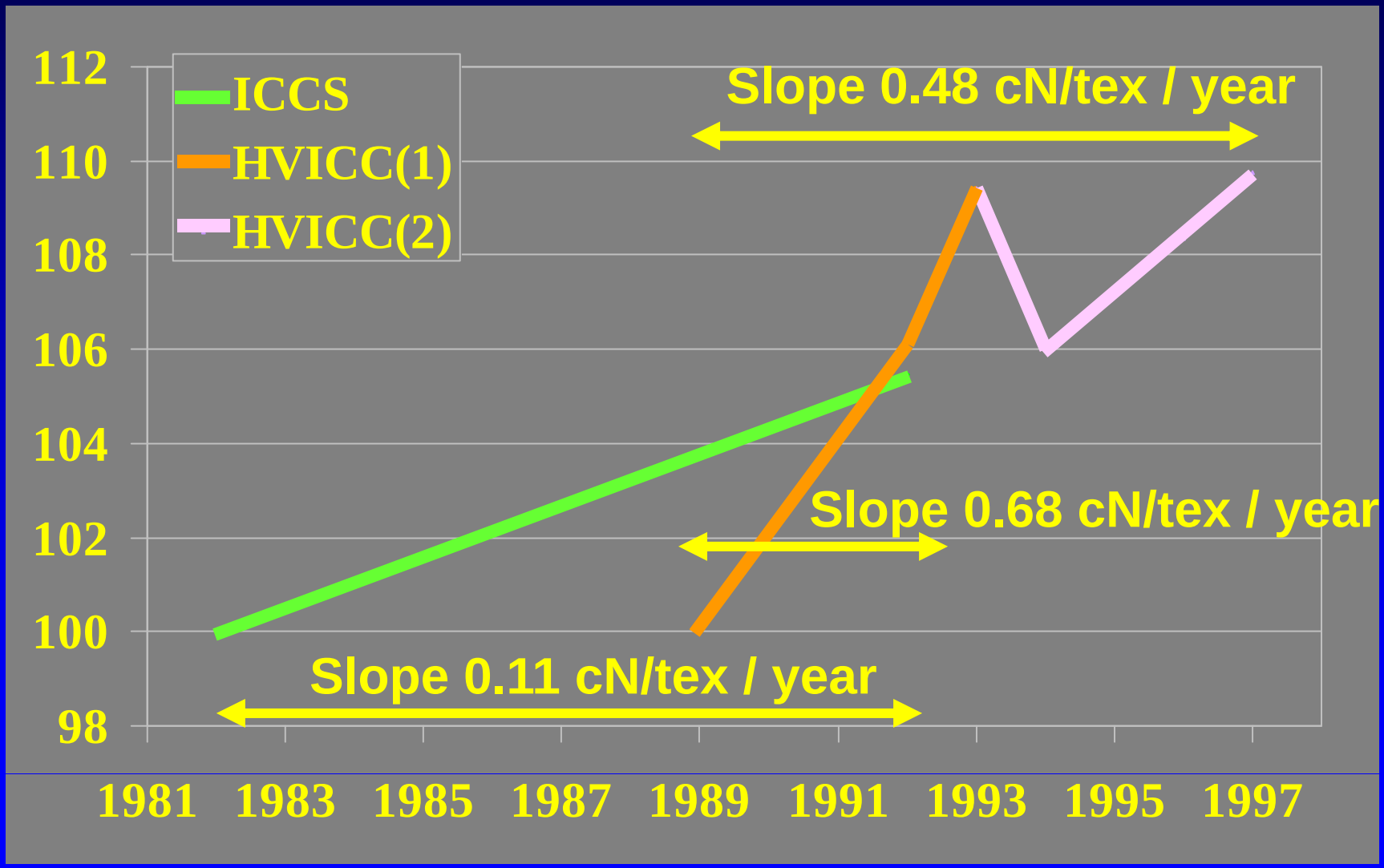
Question : is there any drift in the establishment of Calibration Cotton reference data ?

- **A set of calibration cotton = at least 2 cottons**
- **These can also be analyzed as samples**

Calibration	Samples	Issue/Date
Set 1	Set 1, 2, 3, …	1
Set 2	Set 1, 2, 3, …	2
Set 3	Set 1, 2, 3, …	3

Comparison between results => drift ?

Preliminary experiment



Drift and other troubles

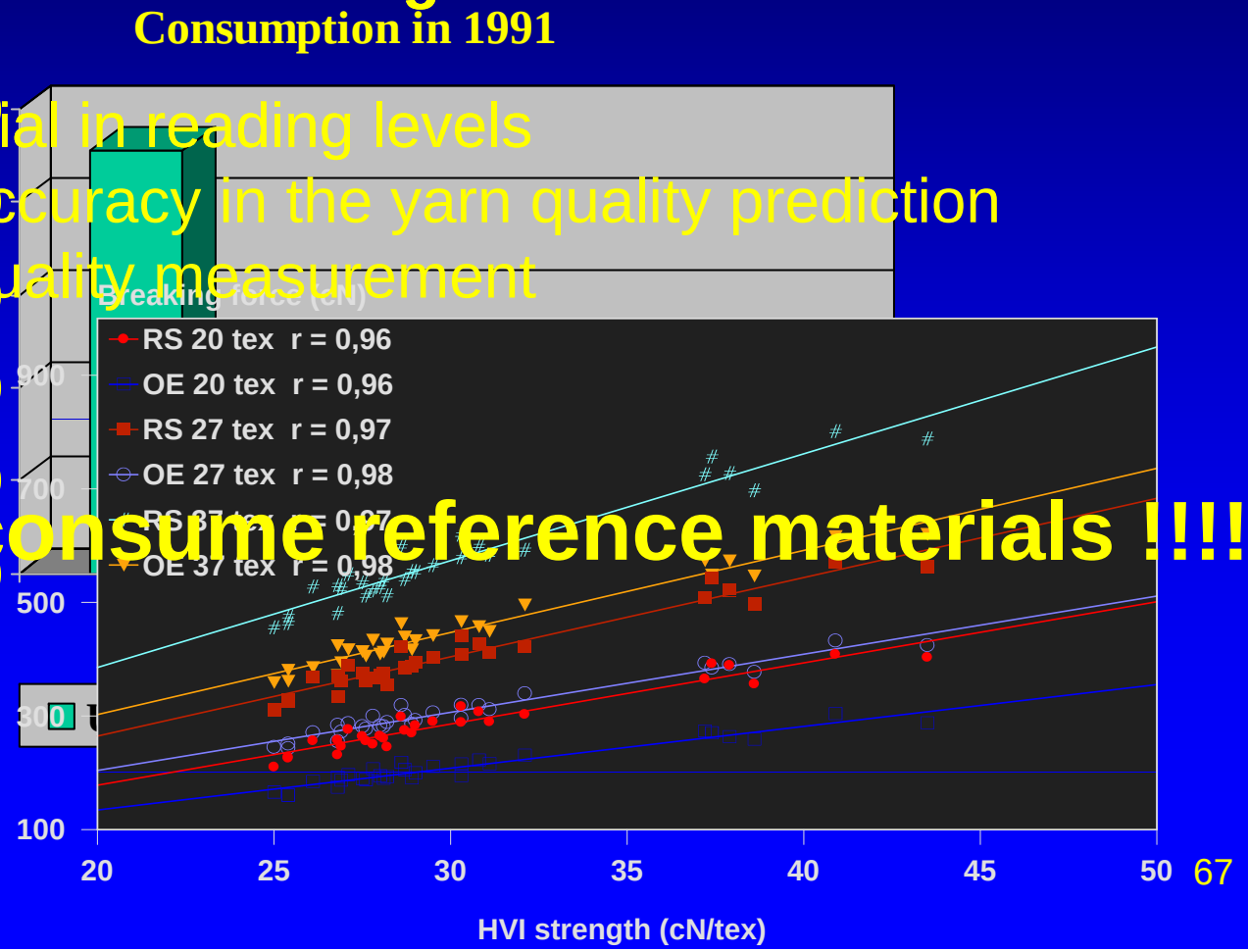
- **Observed Drift**

+ Delay to access to recent generations of reference cottons

=> Differential in reading levels

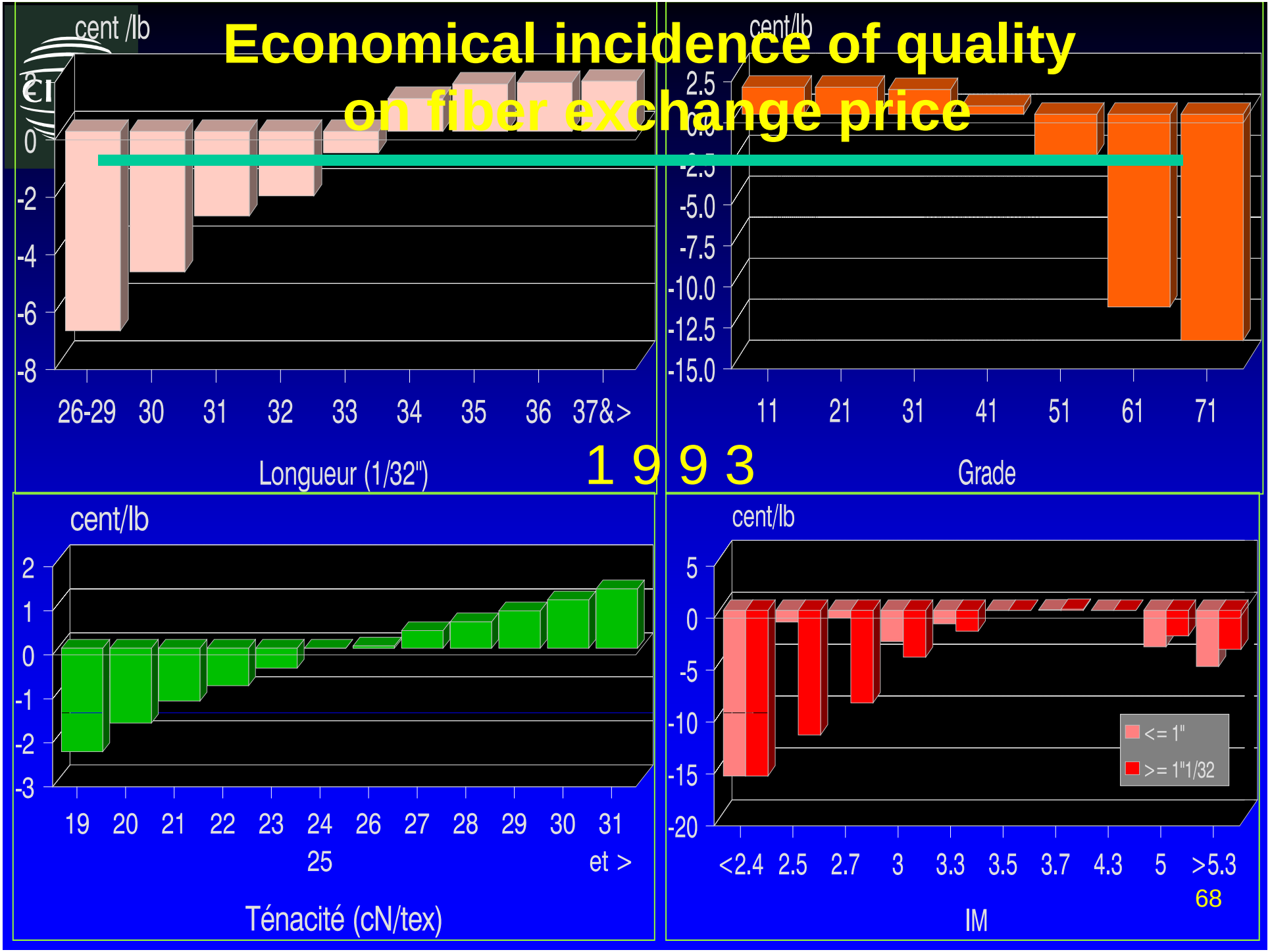
=> Lower accuracy in the yarn quality prediction from fiber quality measurement

Relations between yarn versus fiber quality

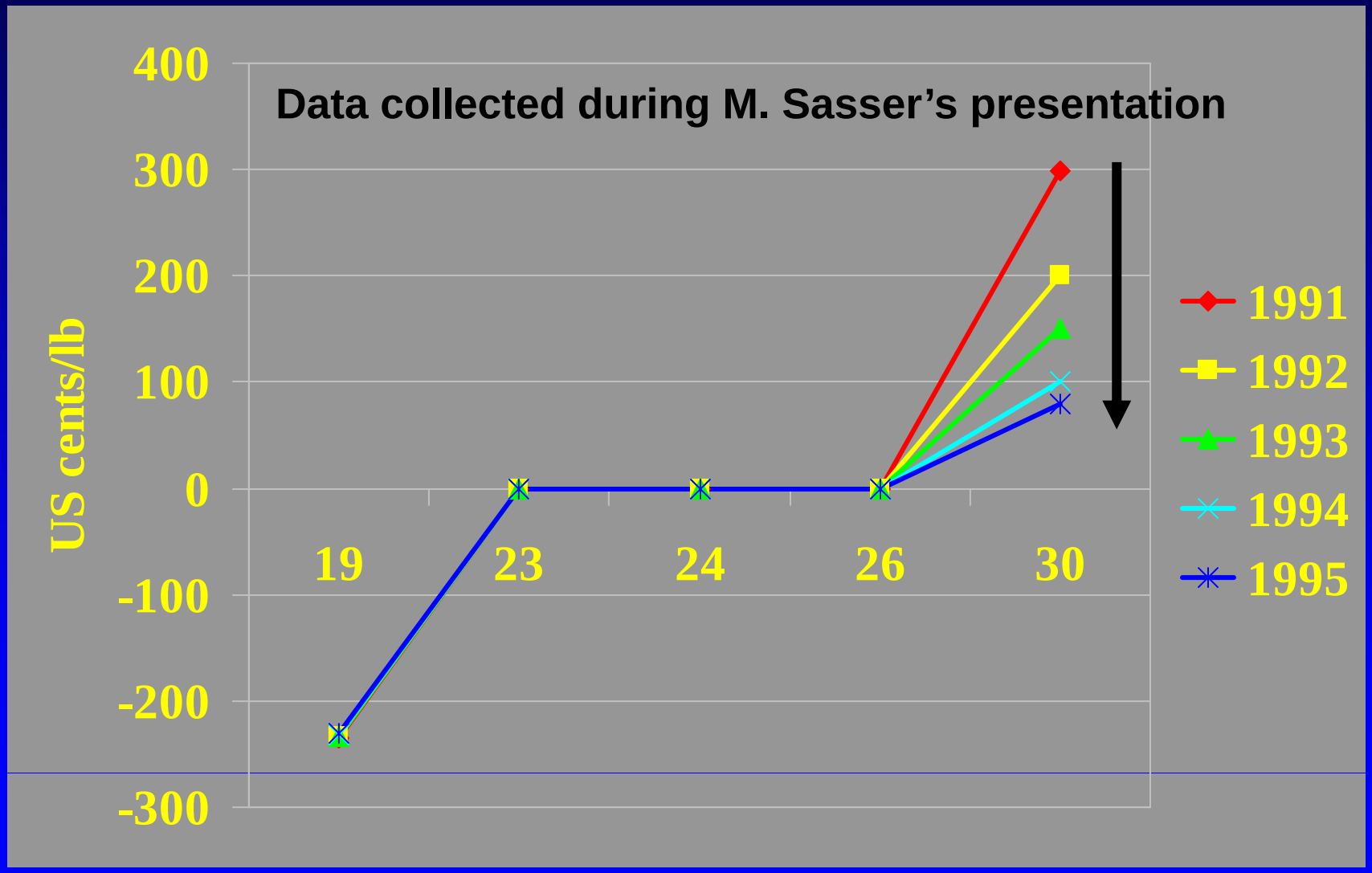


=> Use / consume reference materials !!!!

Economical incidence of quality on fiber exchange price



Evolution of premium/discounts for HVI strength over 5 years (P. SASSER EFS 1995)



Plan of presentation

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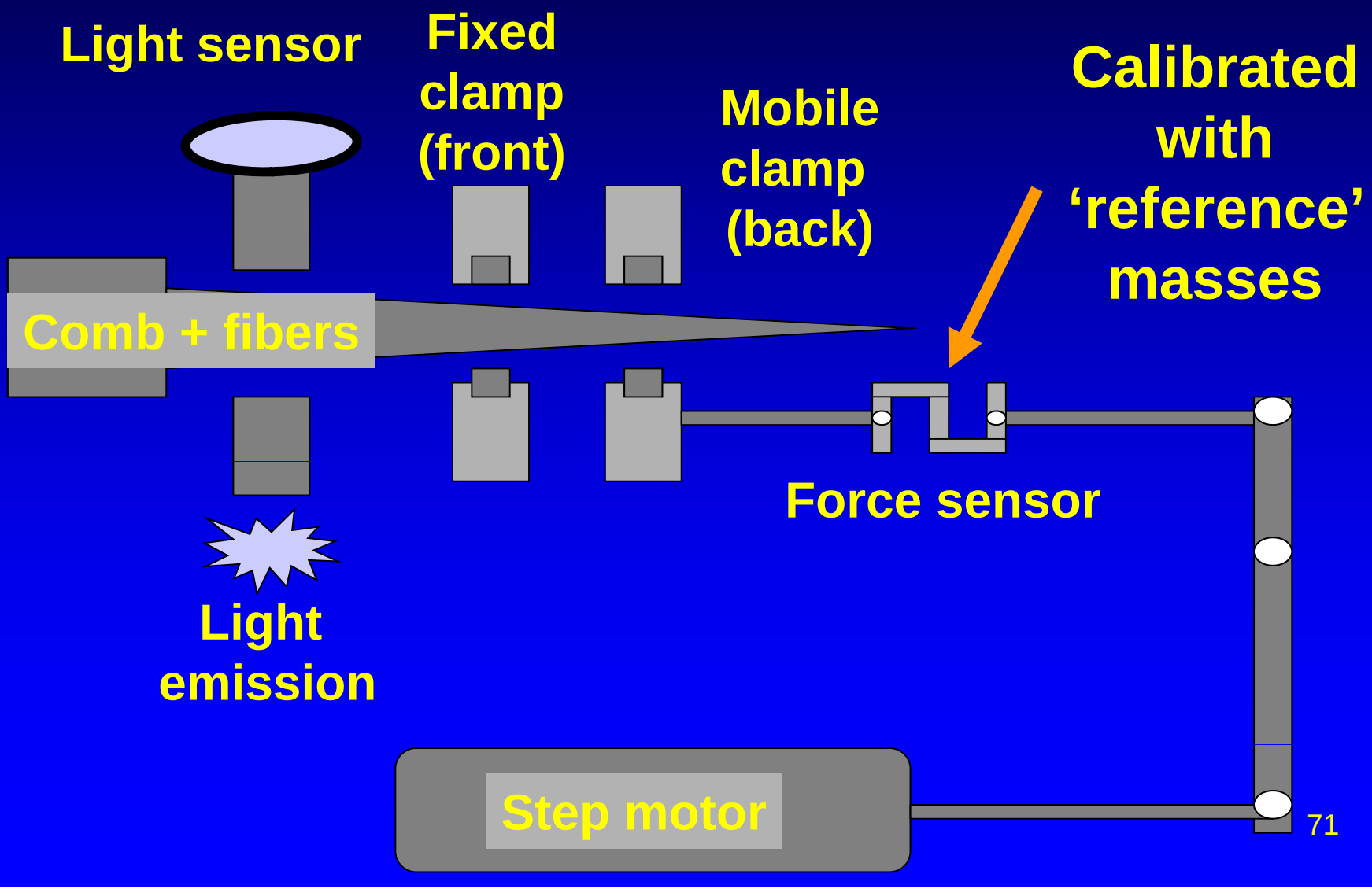
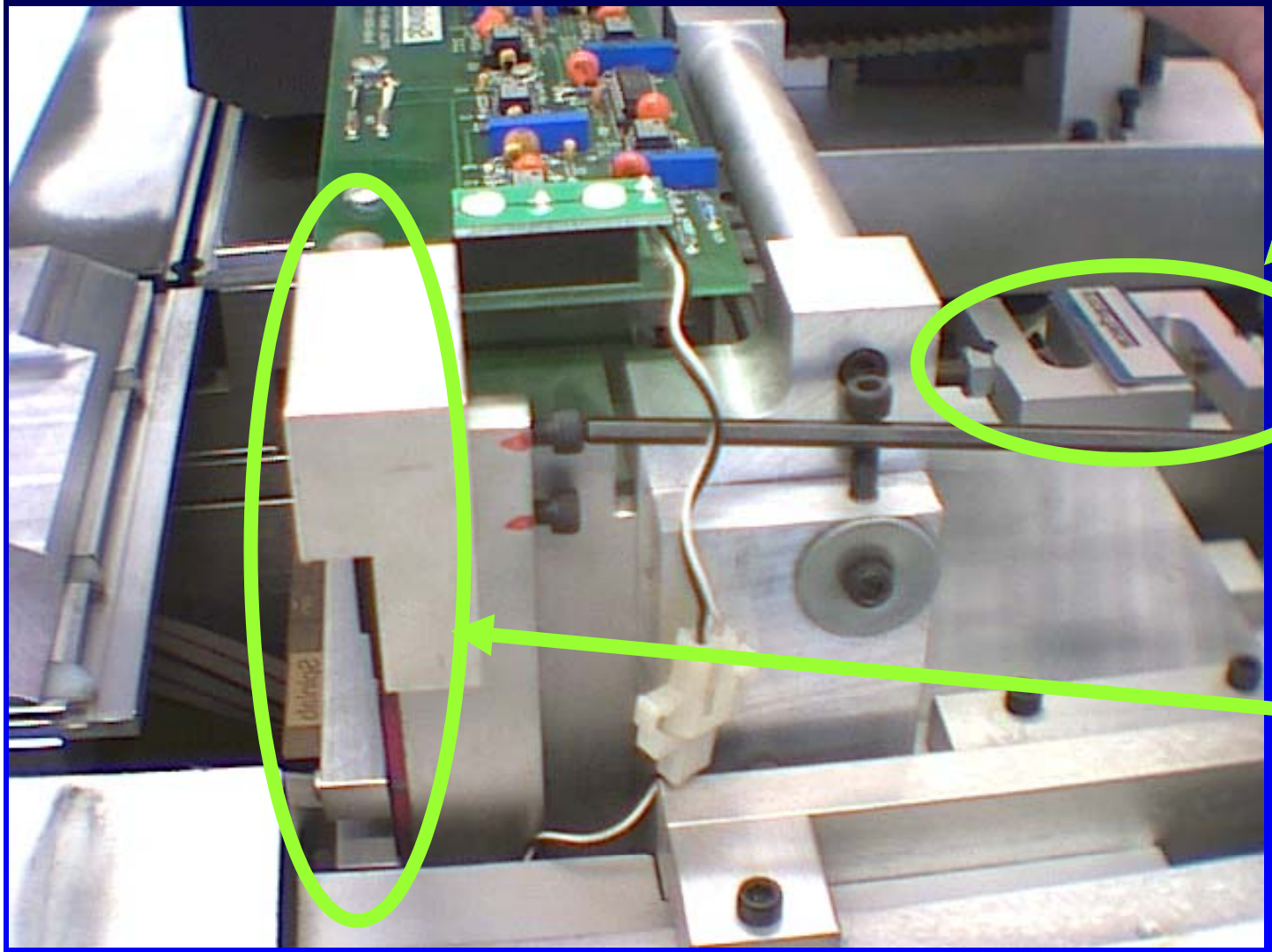
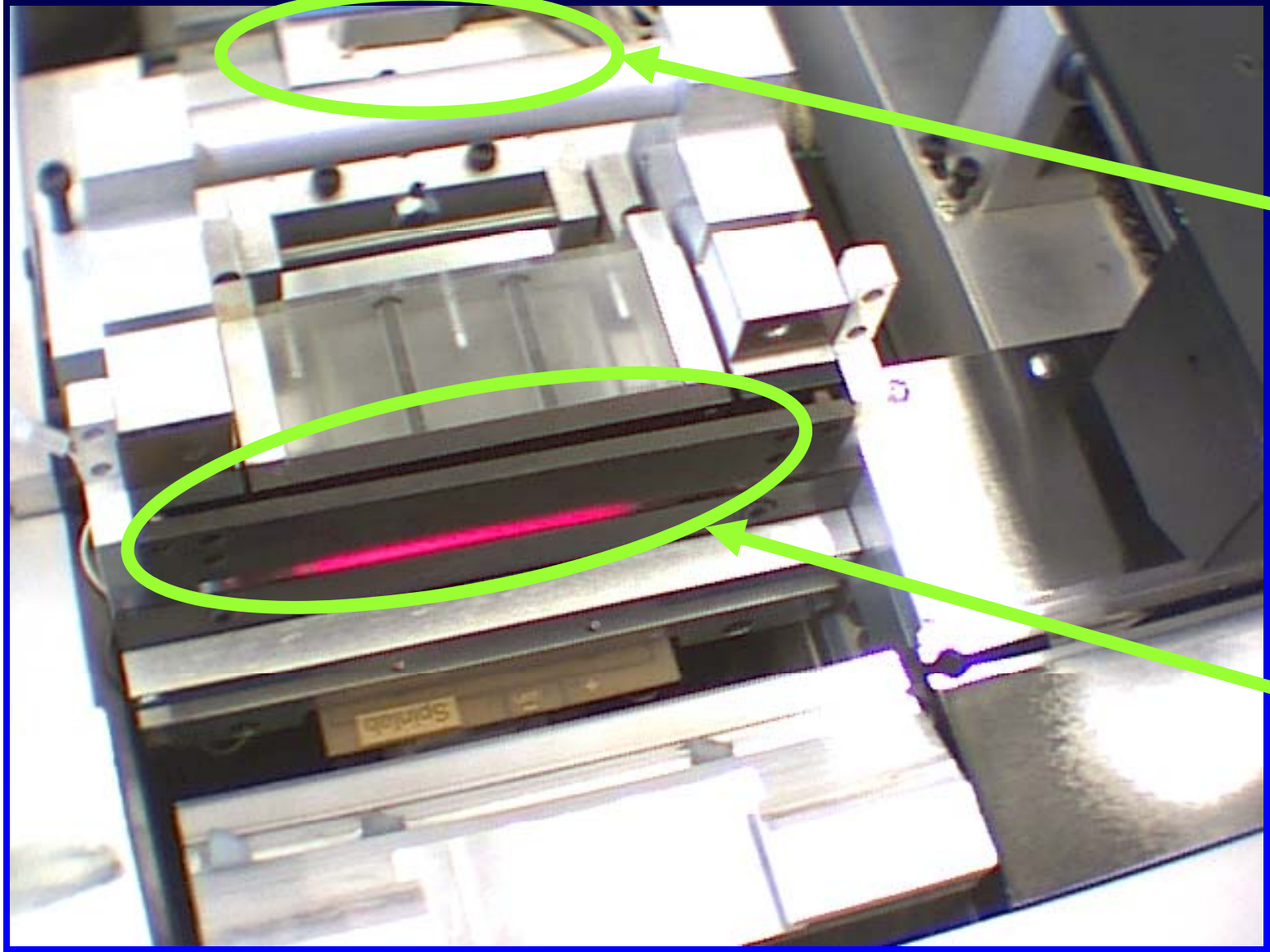
Hardware design



Tenacity Material



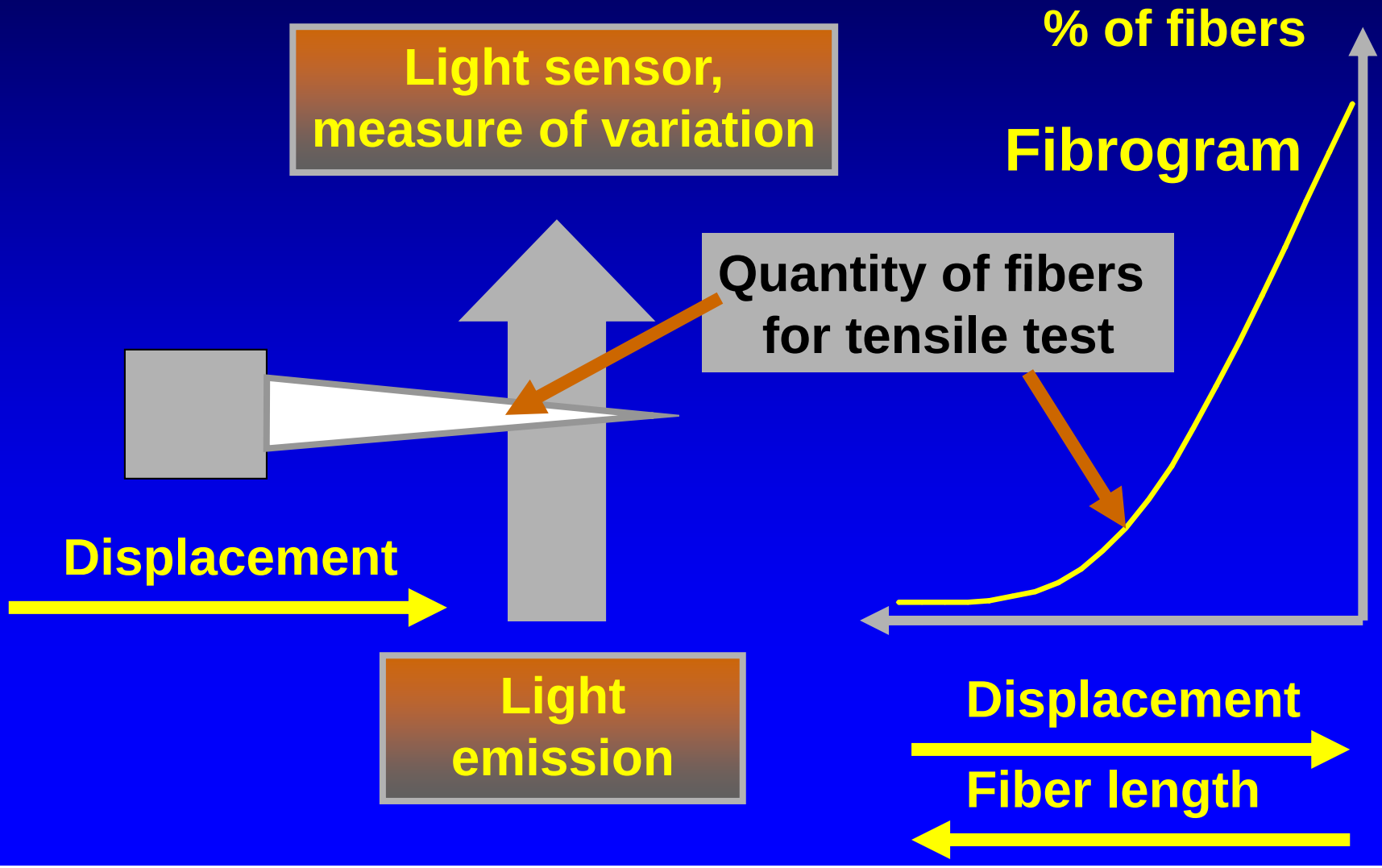
Tenacity
Material



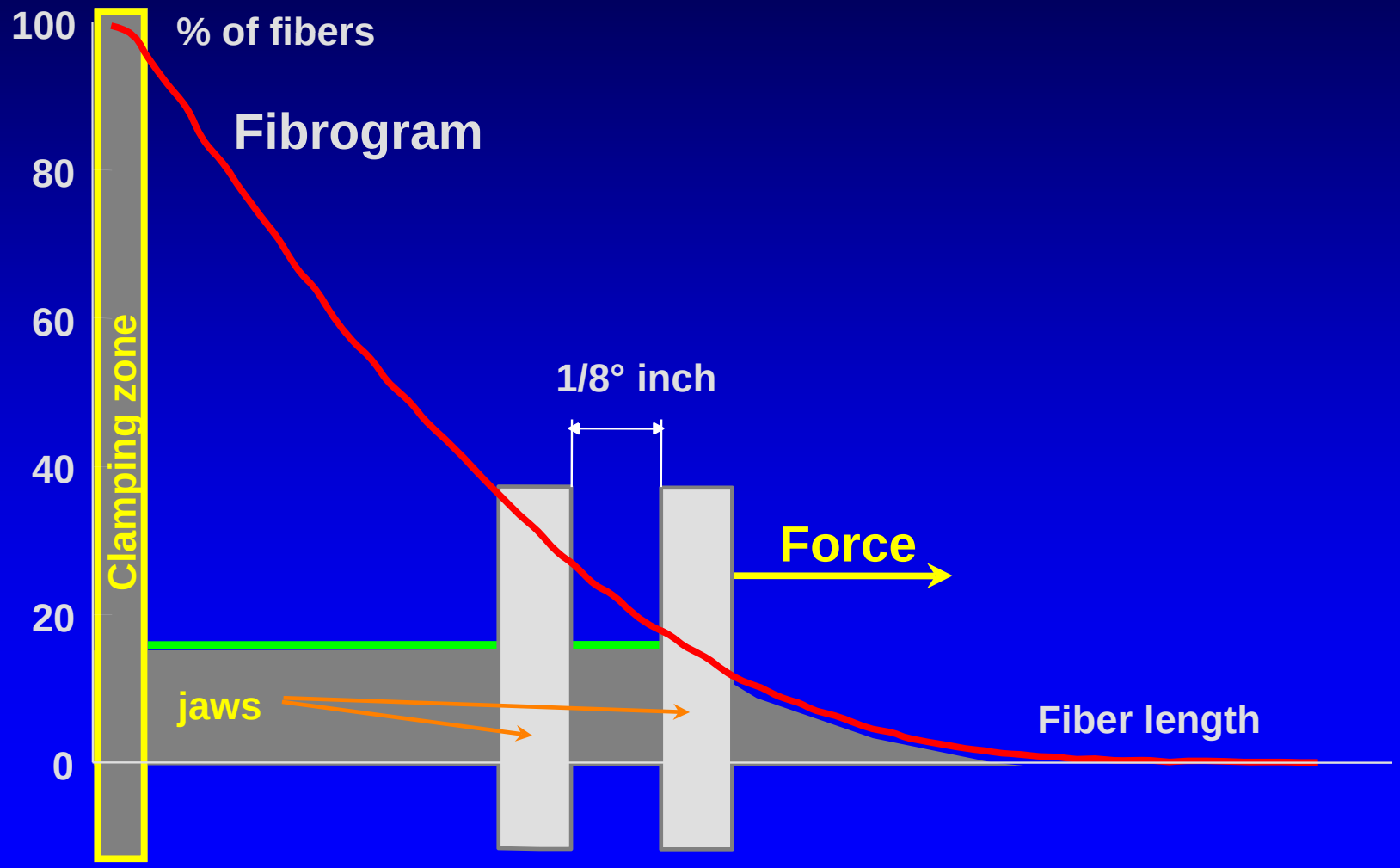
Force sensor

Traction jaws

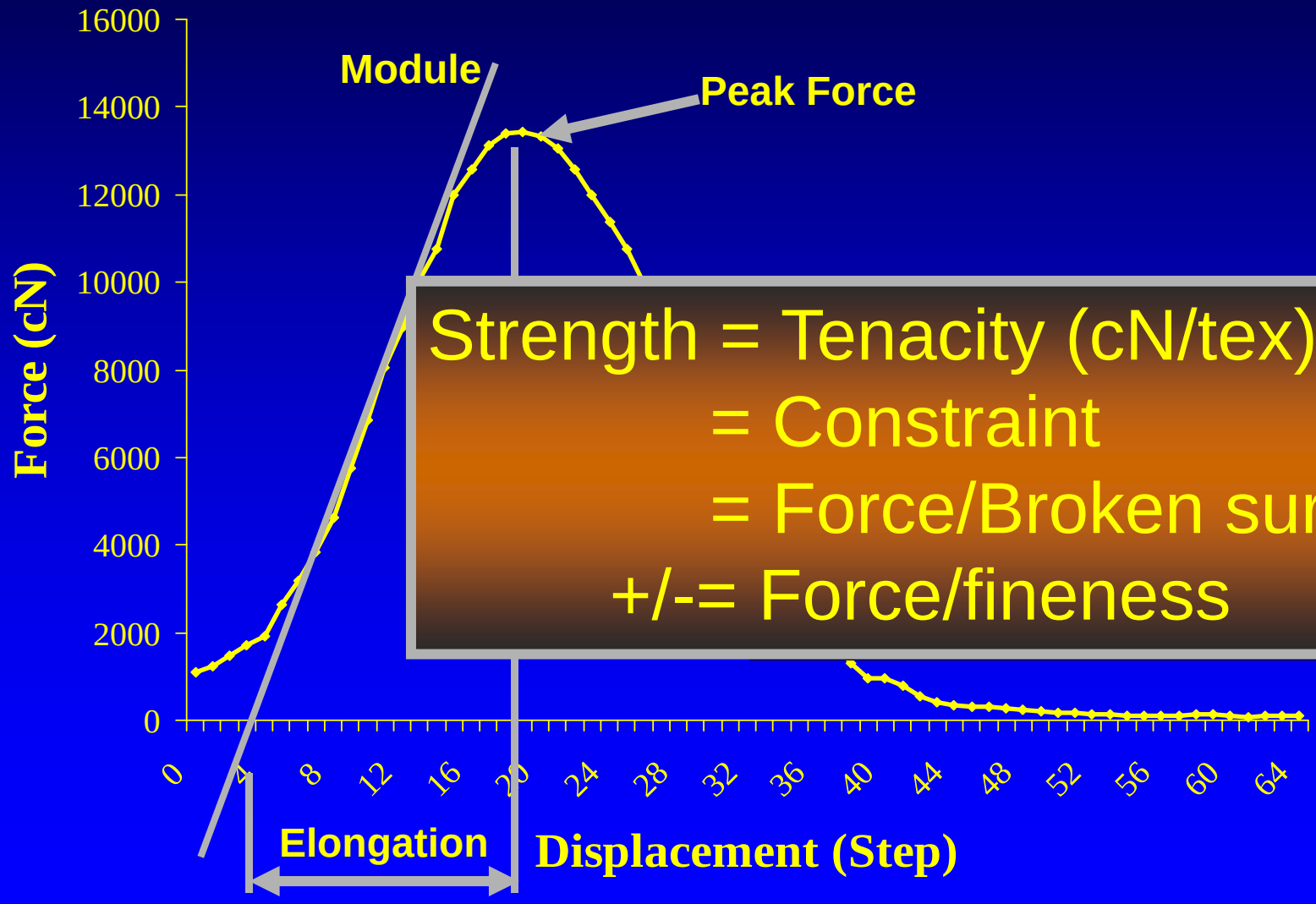
Fibrogram curve



Fibrogram curve

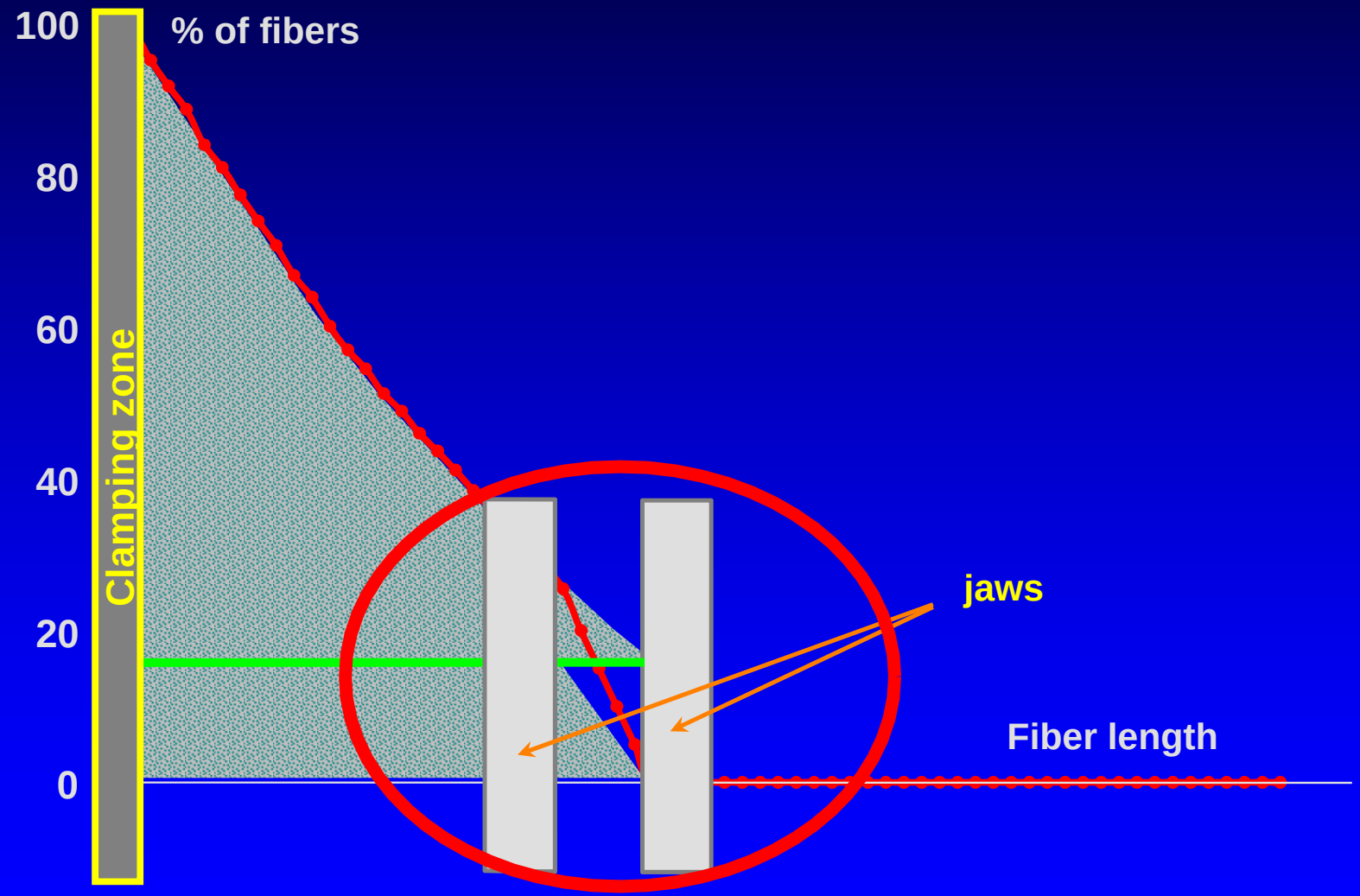


Force / elongation curve

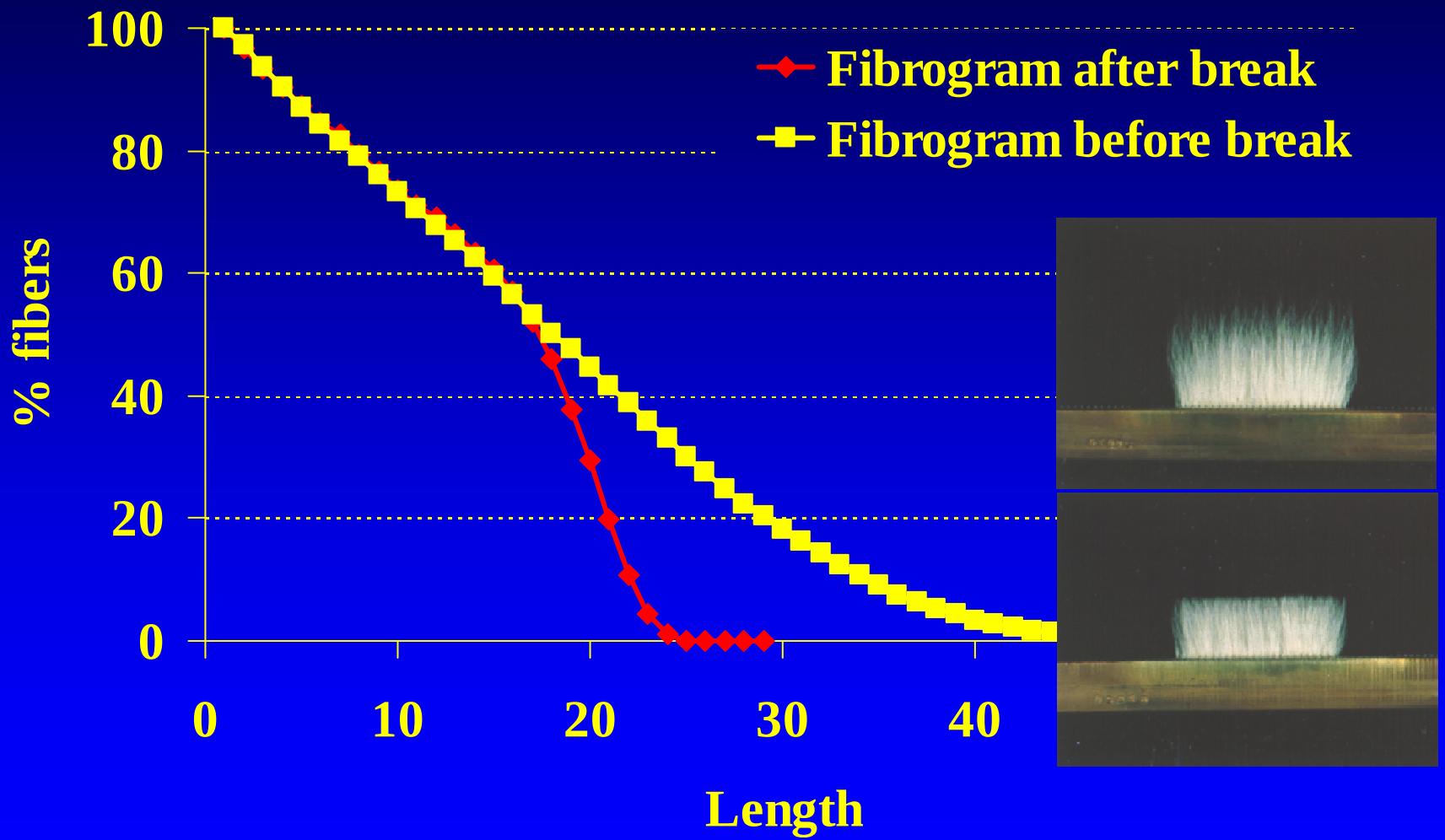


Strength = Tenacity (cN/tex)
= Constraint
= Force/Broken surface
+/-= Force/fineness

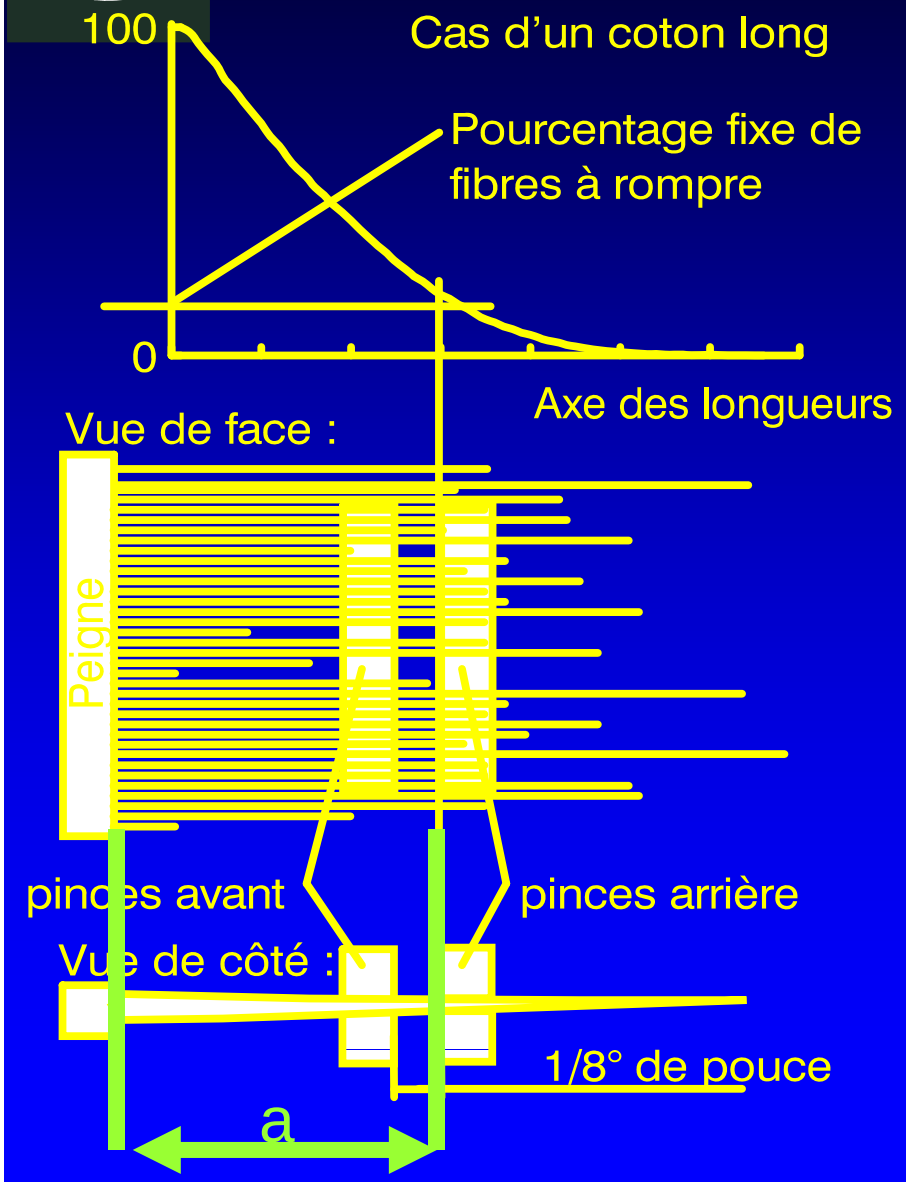
Fibrogram curve after a break

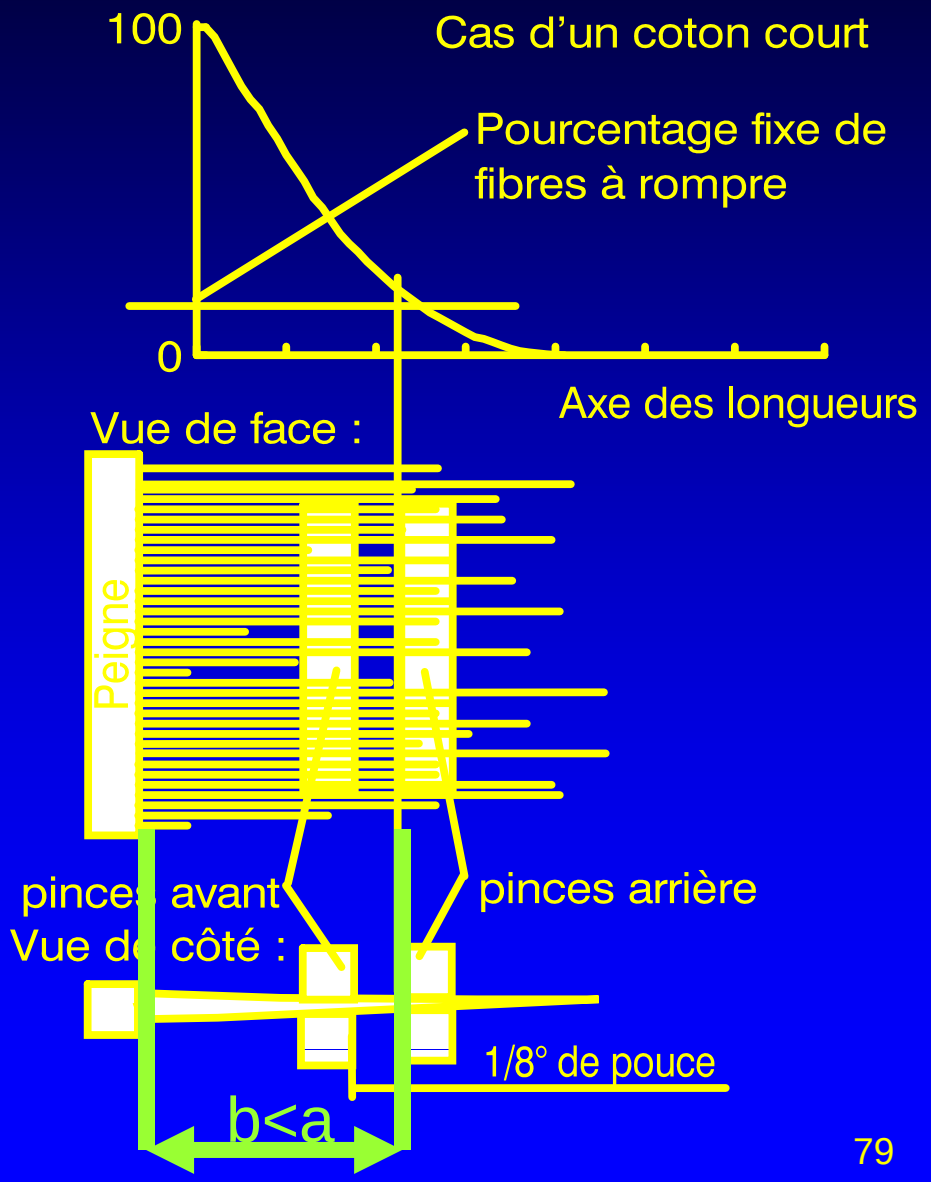


Fibrograms

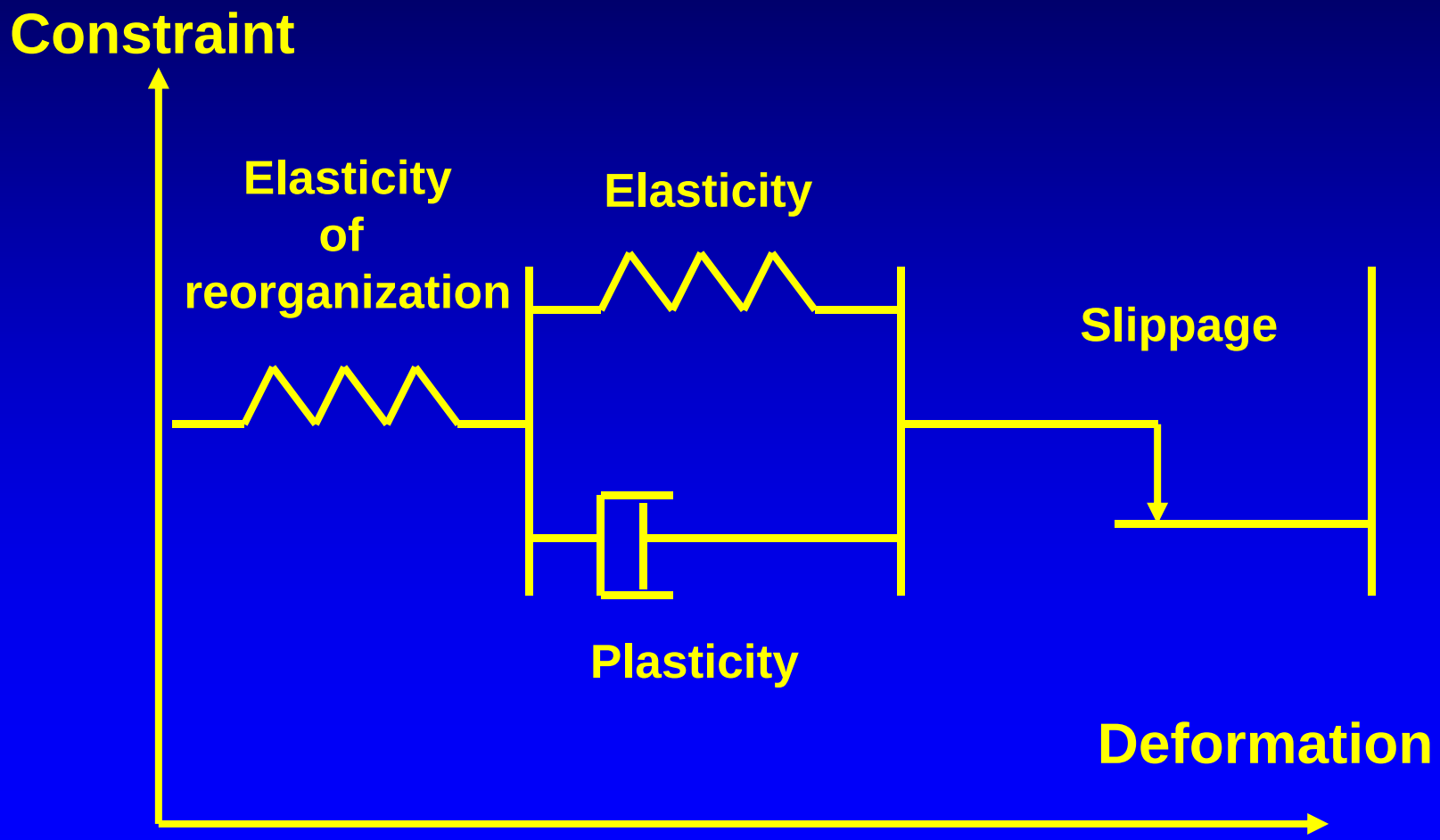

100
80
60
40
20
0
% fibers
0
10
20
30
40
Length
Fibrogram after break
Fibrogram before break

Position of the break





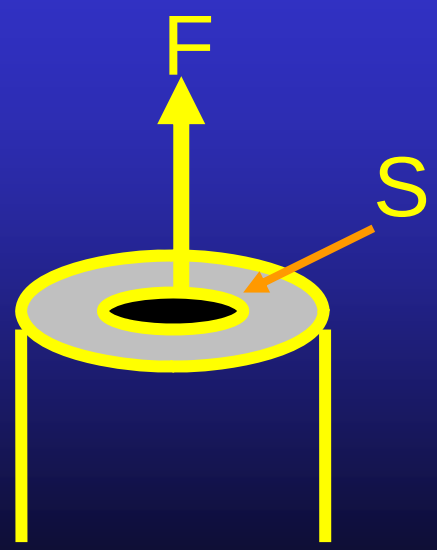
Rheology


Constraint
Elasticity of reorganization
Elasticity
Slippage
Plasticity
Deformation

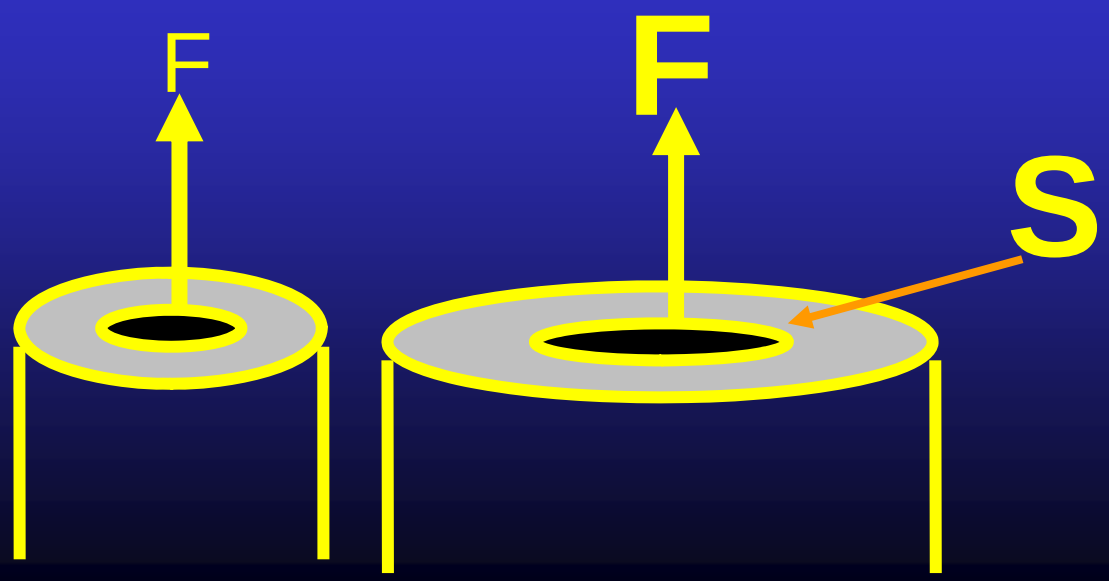
Tenacity or strength

Results and conclusions

HVI

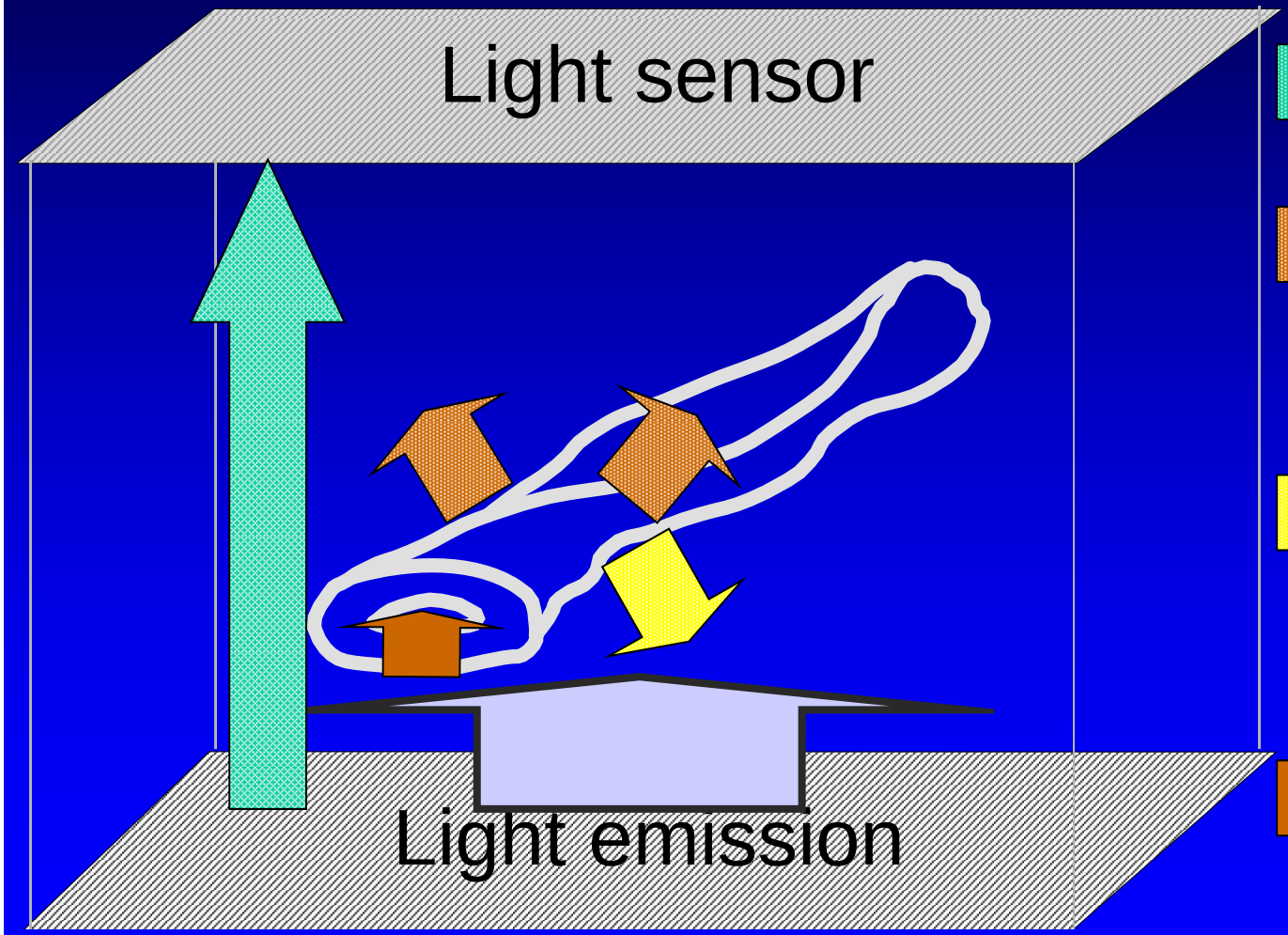


Single fibers



Tenacity ≅ F / S should be constant

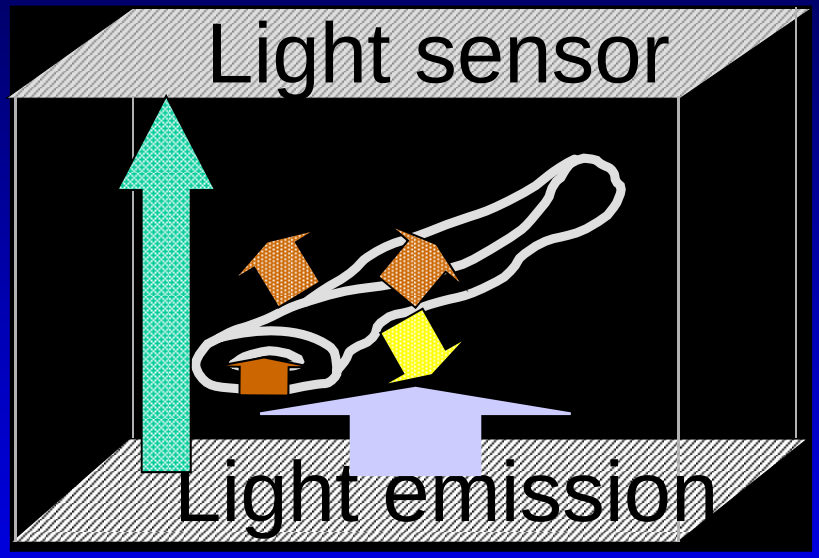
Optical sensor



- Transmission
- Diffraction
  - inside
  - outside
- Scattering
  - inside
  - outside
- Absorption

Original drawing : Gourlot 12/97

Possible effects of fiber properties (example on strength)



Attention: the mass of broken fibers is estimated from this signal for the calculation of strength

- 1-Sensor linearity
- 2-Shape factor
  - micronaire
  - scouring / swelling
- 3-Maturity and fineness distributions
- 4-Color
- 5-Length distribution
- 6-Ambiant conditions

Ambiant conditions

Should be at any time:

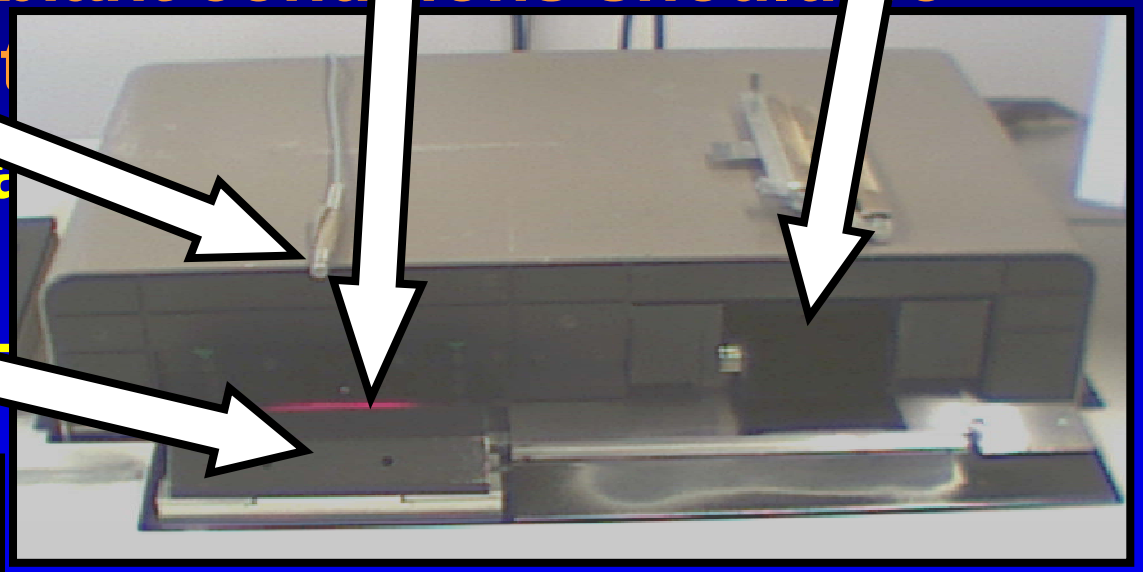
- **21 °C +/- 1 °C**
- **65 % Relative Humidity (RH%) +/- 2 %**

Ambiant conditions

Material and method

Hypothesis : ambiant conditions should be stable around t

- Use of tempera probes
- Use of HVI or



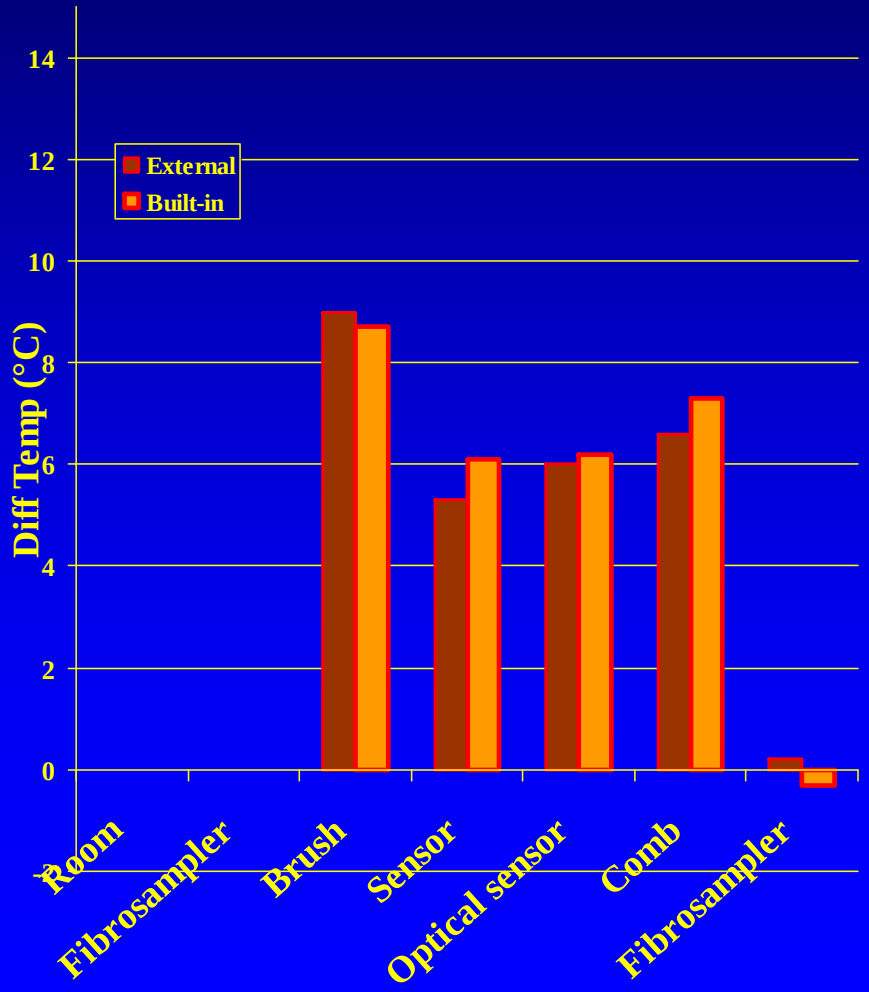
Ejection

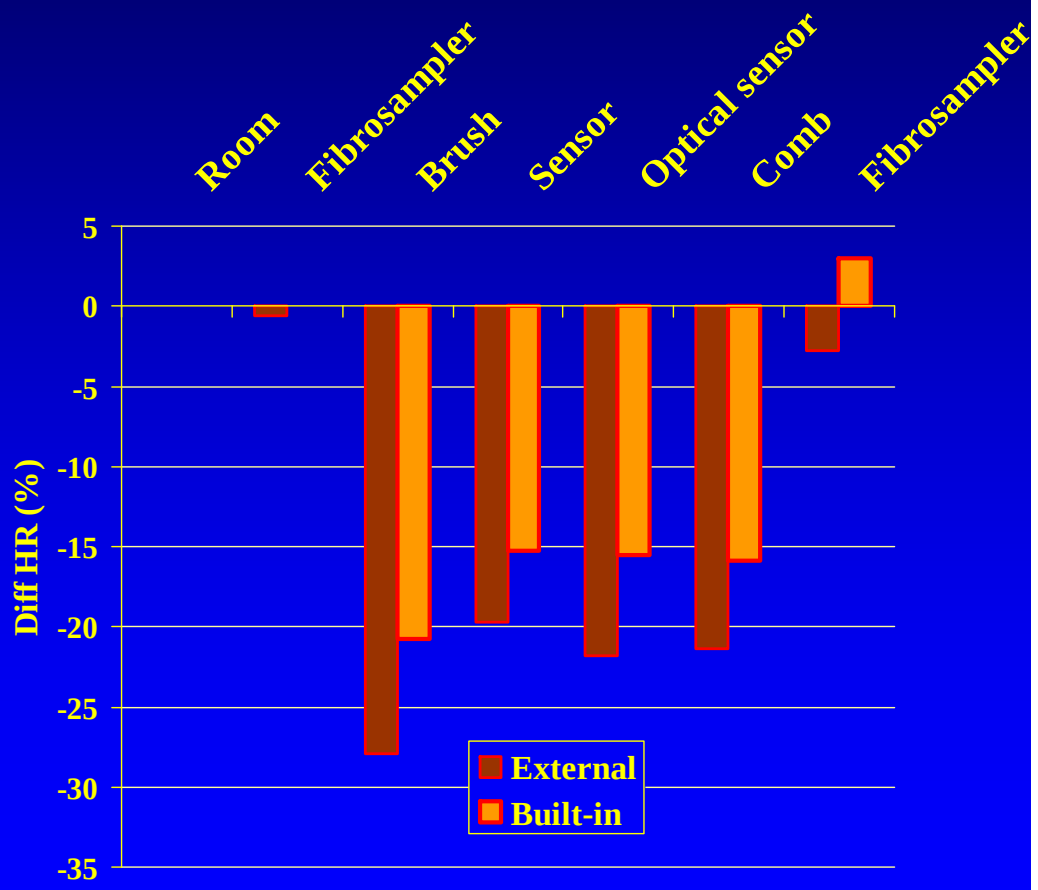
Fibrosampler

Air ejection OFF
ON

Ambiant conditions

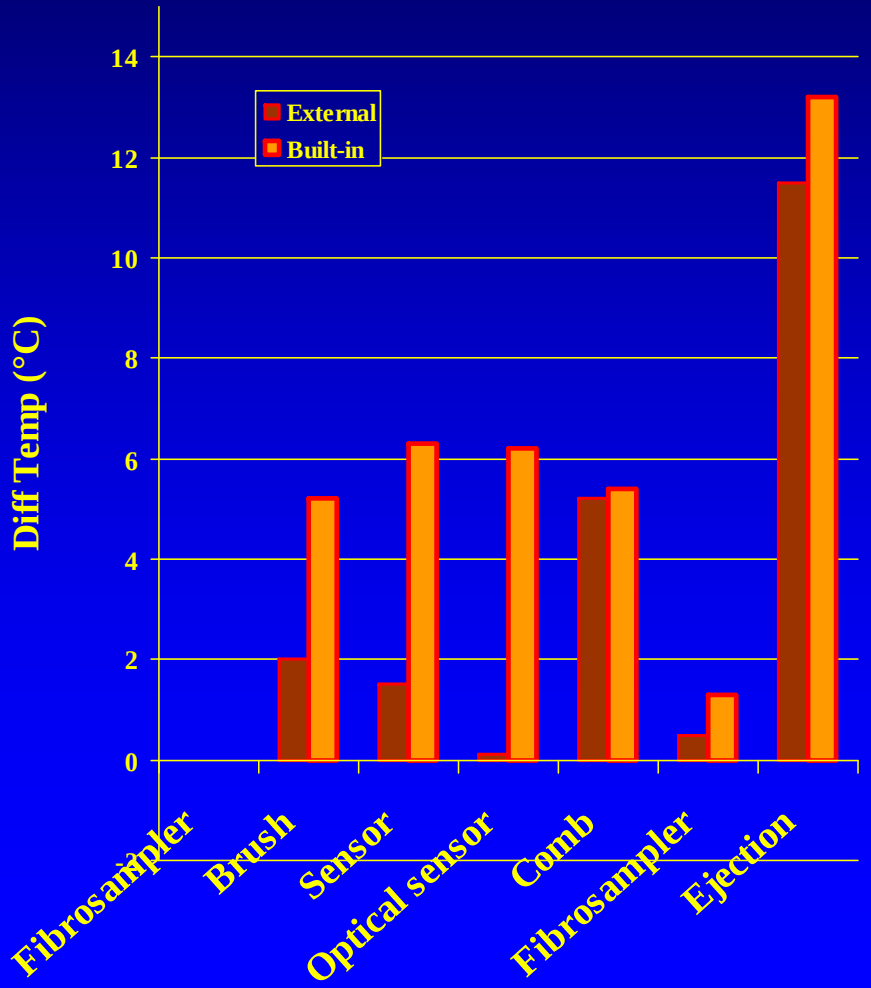
Results and conclusions : air succion OFF

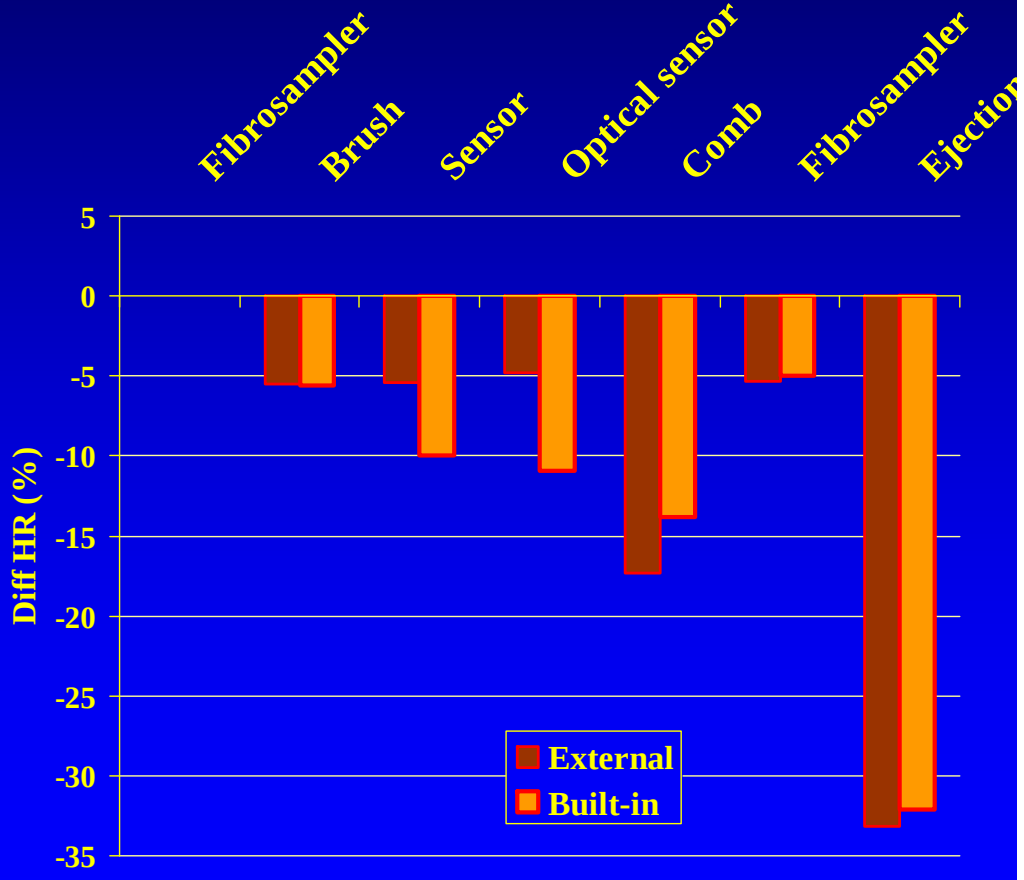


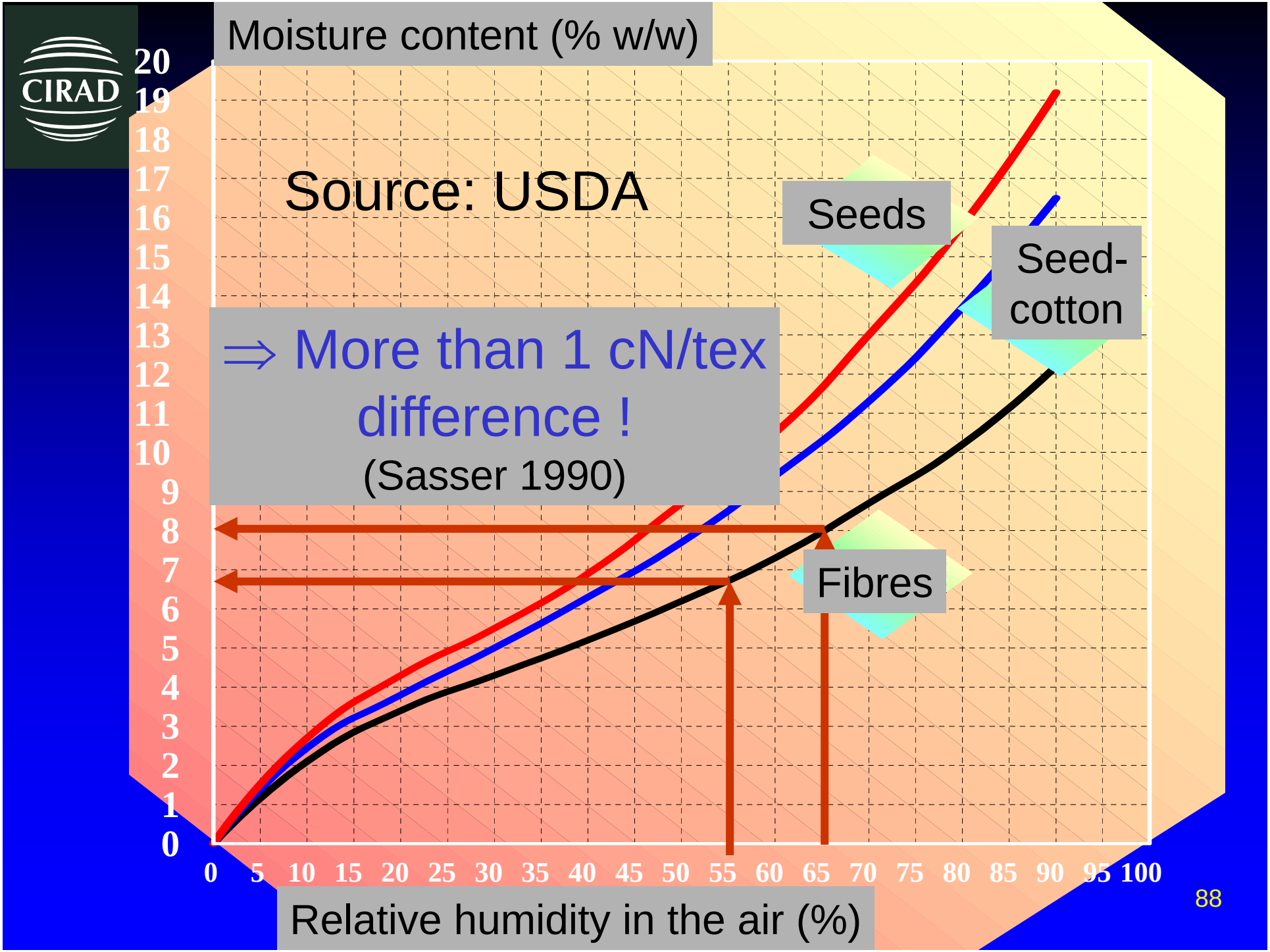


Ambiant conditions

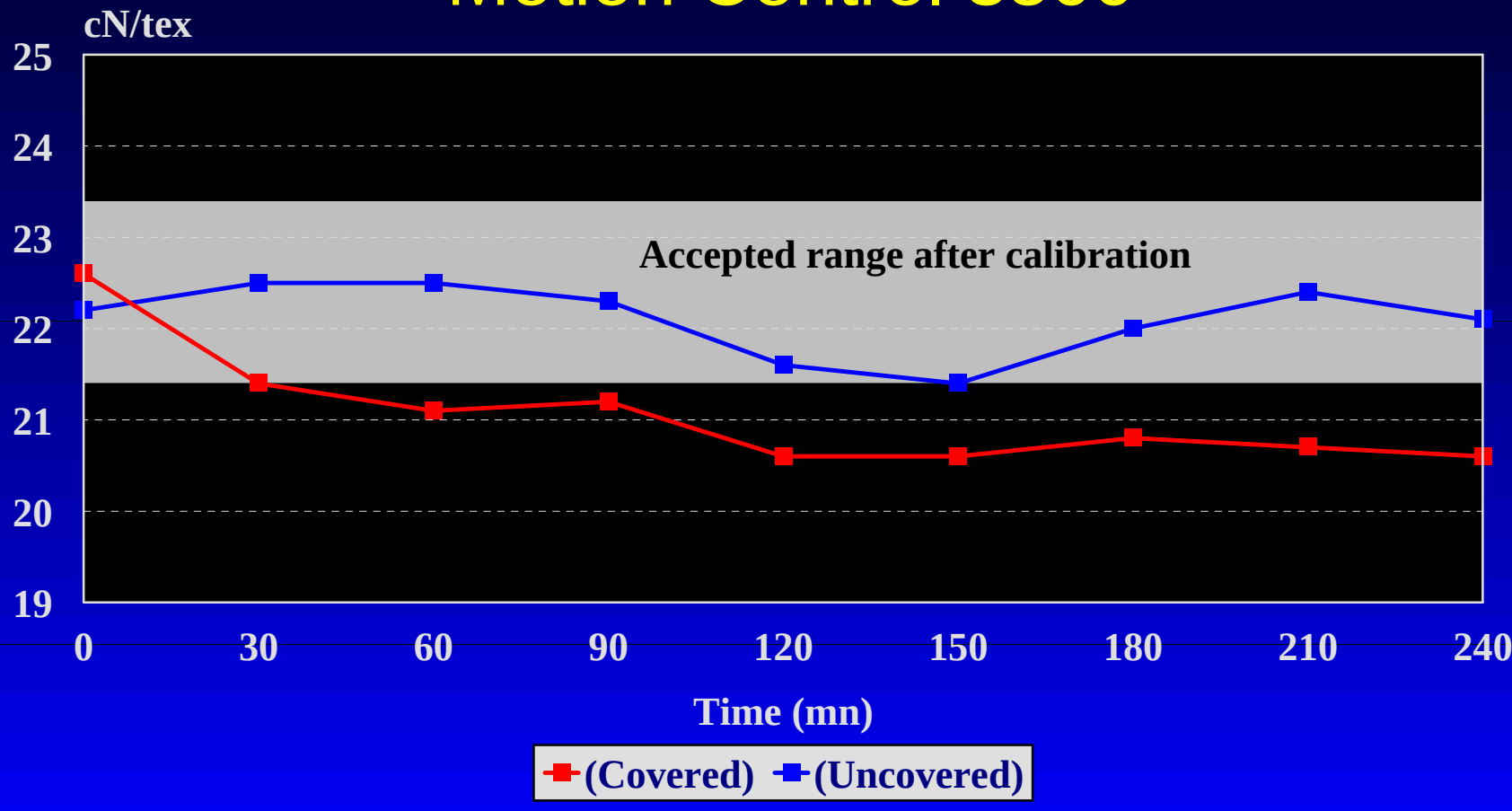
Results and conclusions : air succion ON



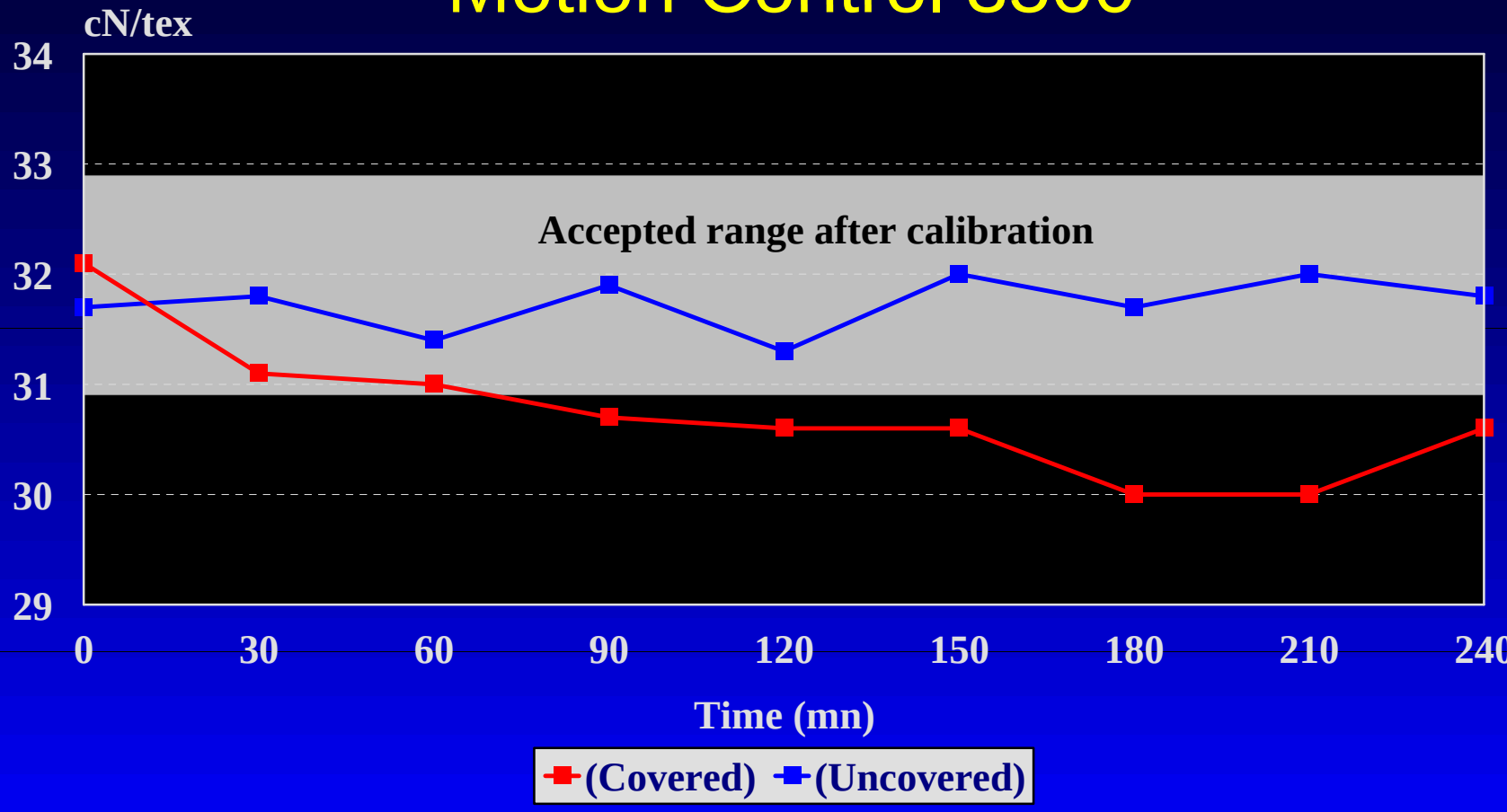



Moisture content (% w/w)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Source: USDA
Seeds
Seed-cotton
⇒ More than 1 cN/tex difference !
(Sasser 1990)
Fibres
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Relative humidity in the air (%)

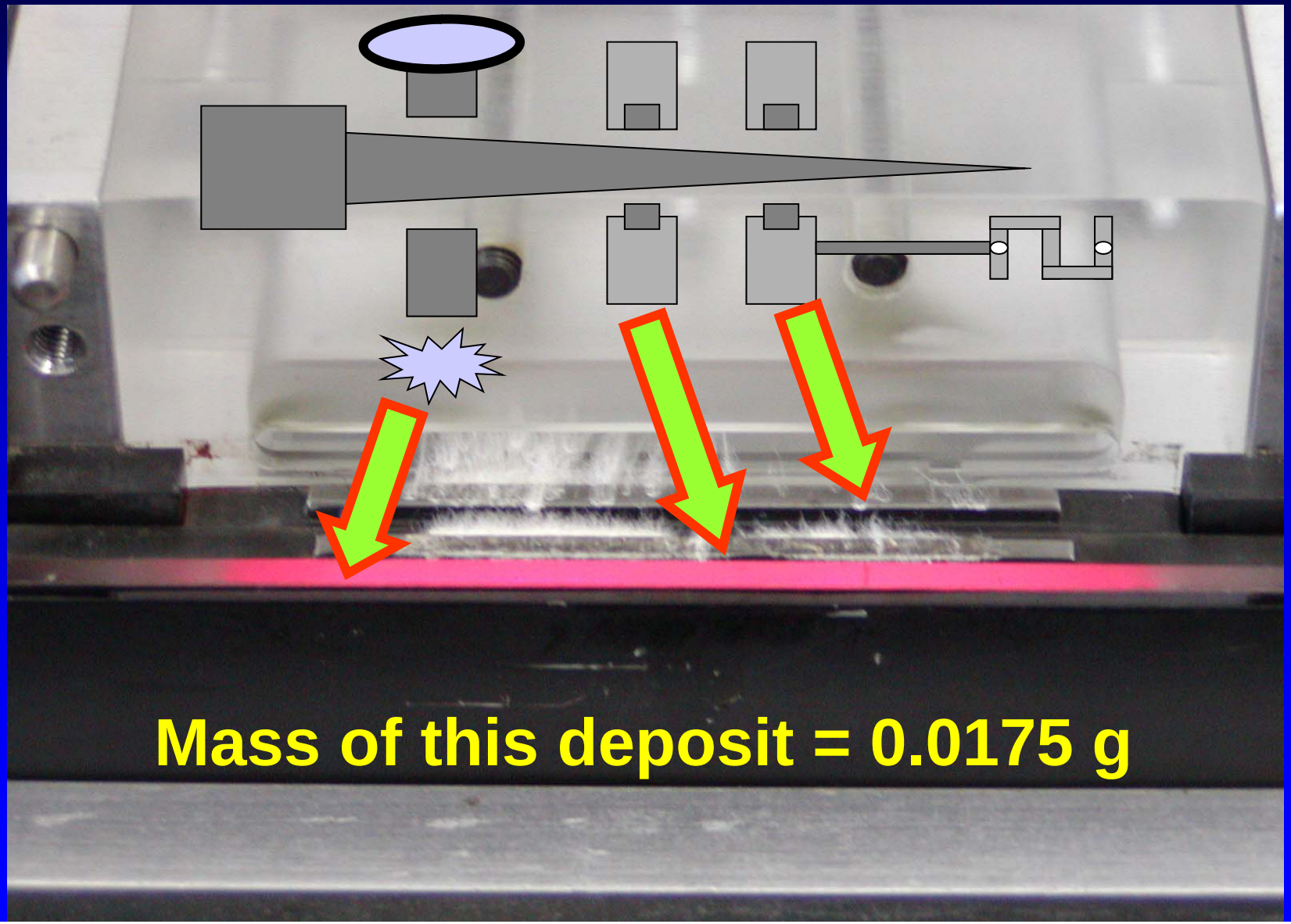
Strength stability : HVICC bale 27985
Measuring unit covered vs uncovered
Motion Control 3500



Strength stability : HVICC bale 28484
Measuring unit covered vs uncovered
Motion Control 3500



Other possible bias in HVI measurement



Sources of variability in the results

Variety
Growing conditions
(fertilizer, insects)

Plant to plant
Picking technique
Farm size

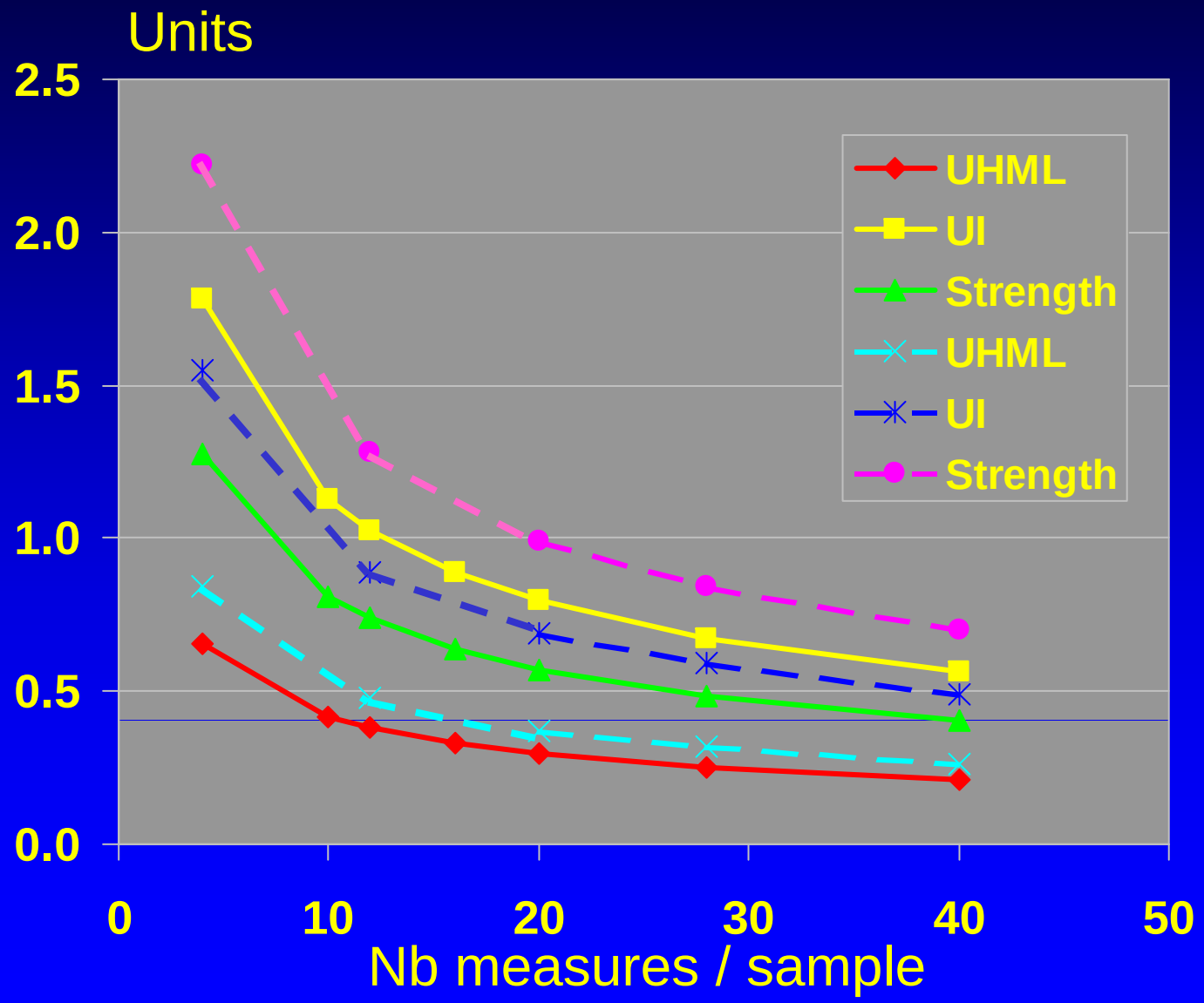
Seed cotton preparation
Ginning technique (R/S)
Lint cleaning

Number of samples / bale
Number of bales / lot
Method of sampling

Precision
Accuracy
Repeatability
Reproducibility

RH conditions,
HVI calibration
Nb tests / sample

Confidence Intervals (research samples in specific sampling conditions)



Upland Saw ginned samples

Barbadense cottons

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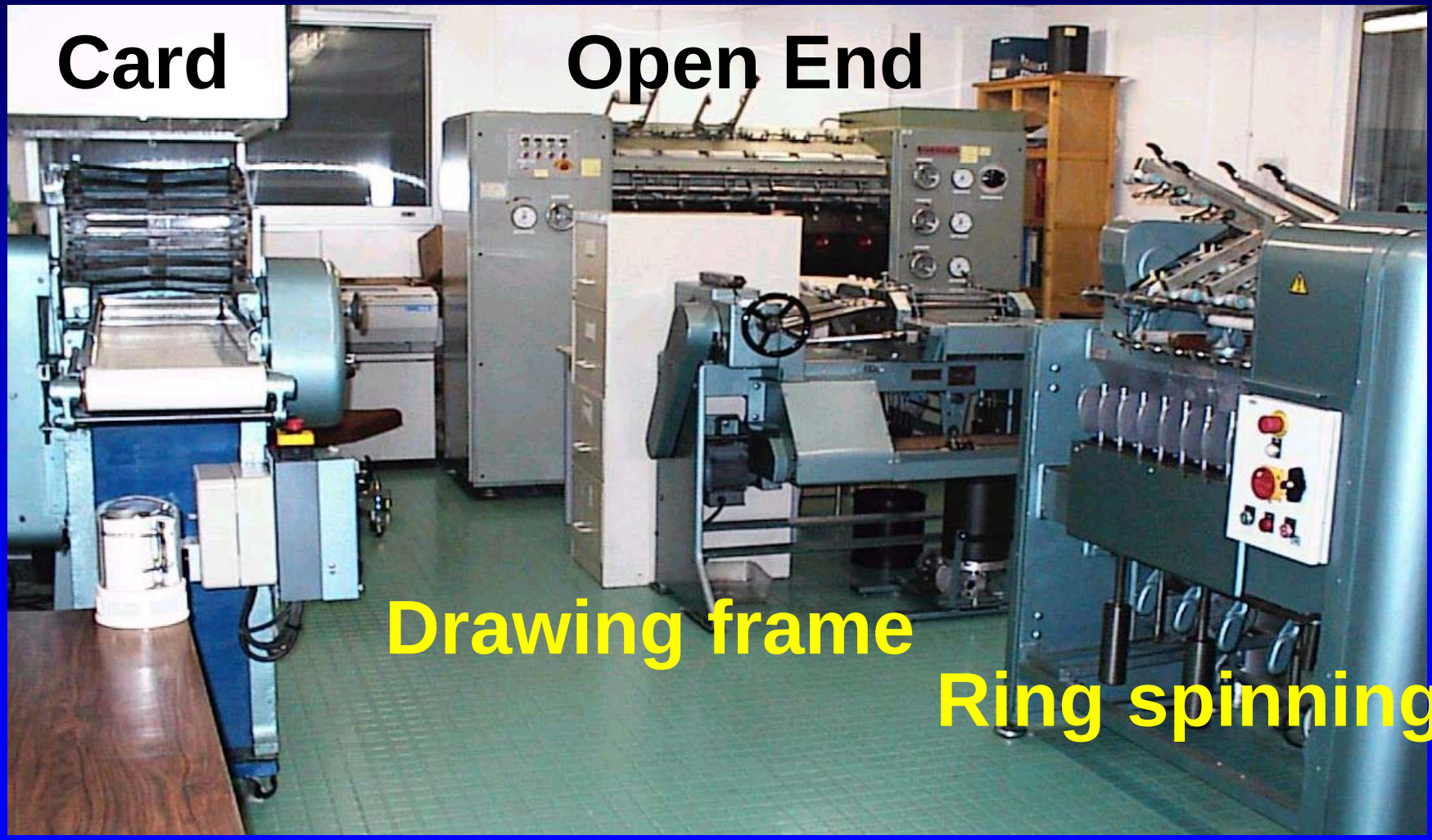
Relations between yarn versus fiber quality

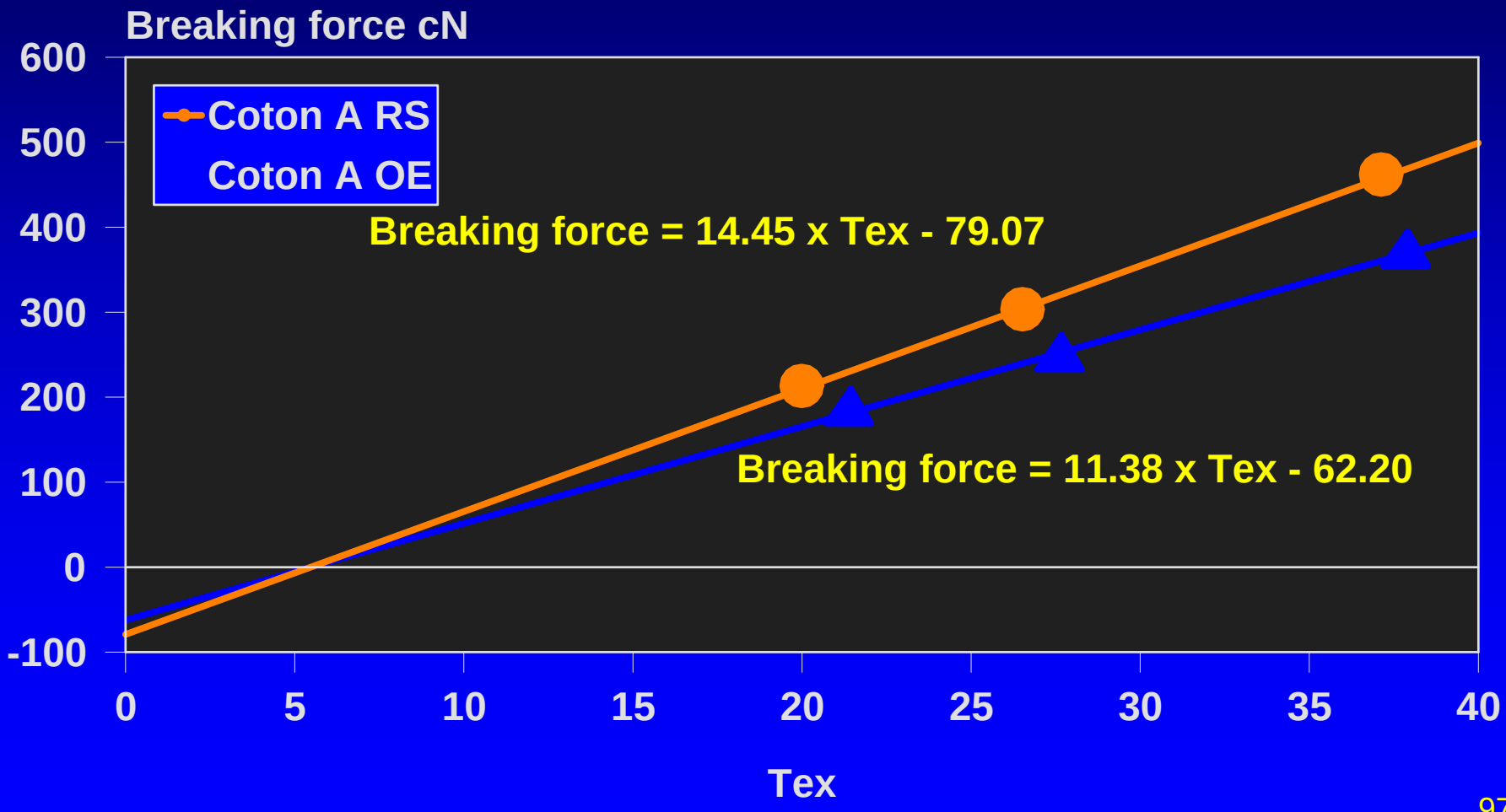


Relations between yarn versus fiber quality

	Coton A	Coton B
ML (mm)	22.6	24.2
UHML (mm)	28.4	28.9
UI (%)	79.6	83.7
Strength (cN/tex)	25	30.3
Elong (%)	5.0	5.7
IM	2.9	3.8
MR	0.67	0.90
PM (%)	58.5	79.6
H (mtex)	143	155
HS (mtex)	214	173
Rd (%)	69.7	72.8
+b	11.9	11.3

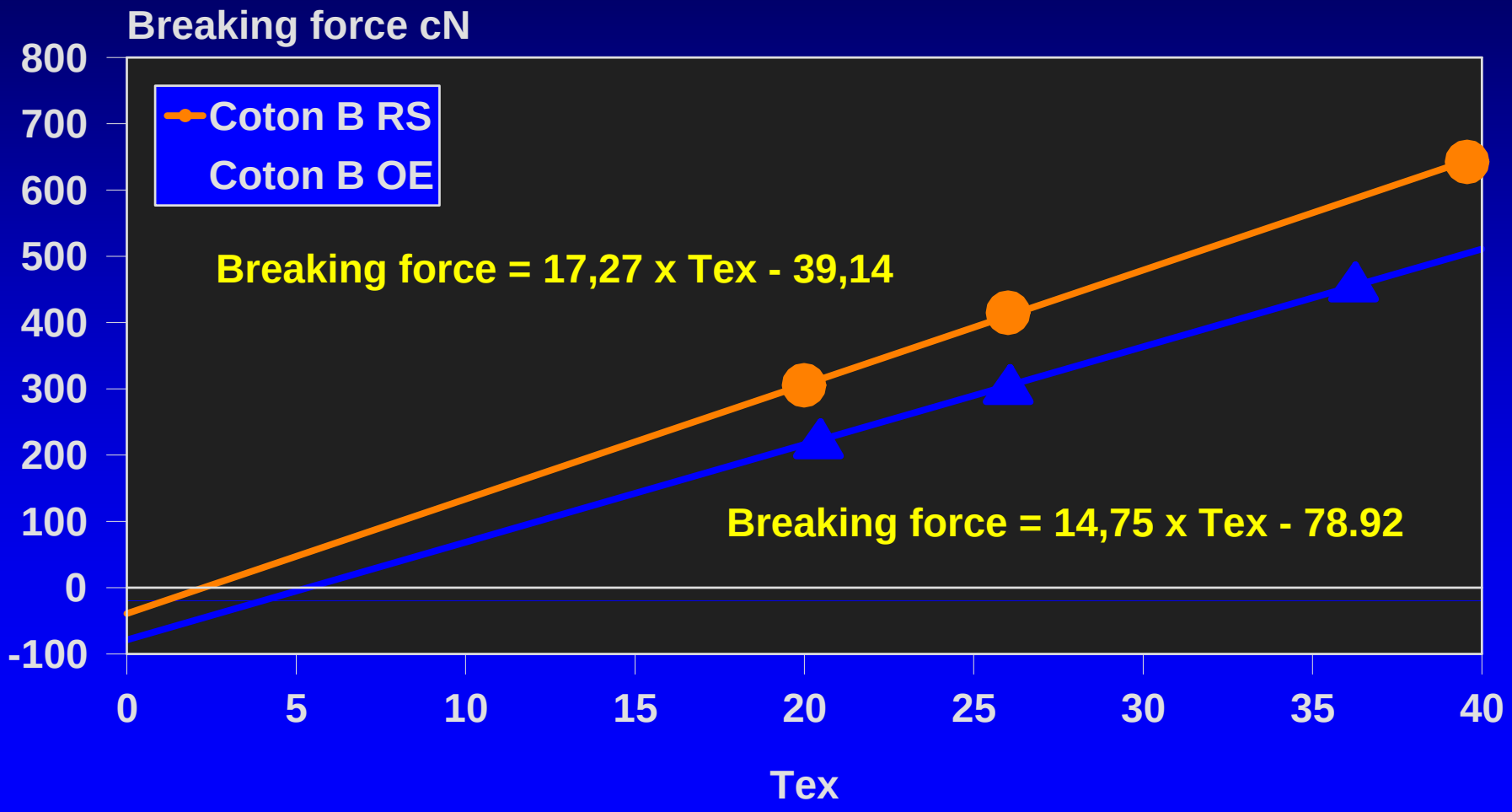
Relations between yarn versus fiber quality

CRL yarn tenacity tests



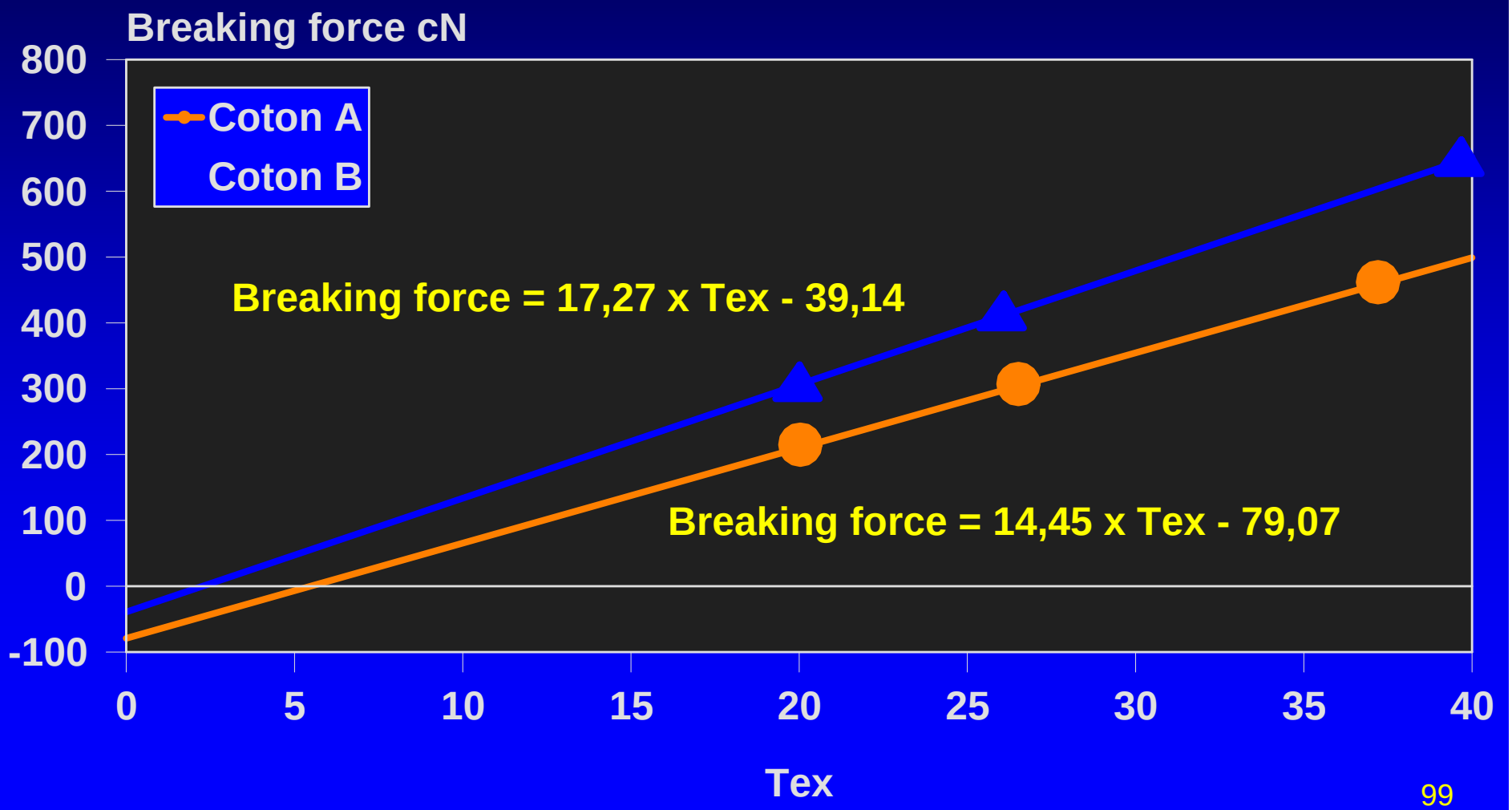
Relations between yarn versus fiber quality

CRL yarn tenacity tests



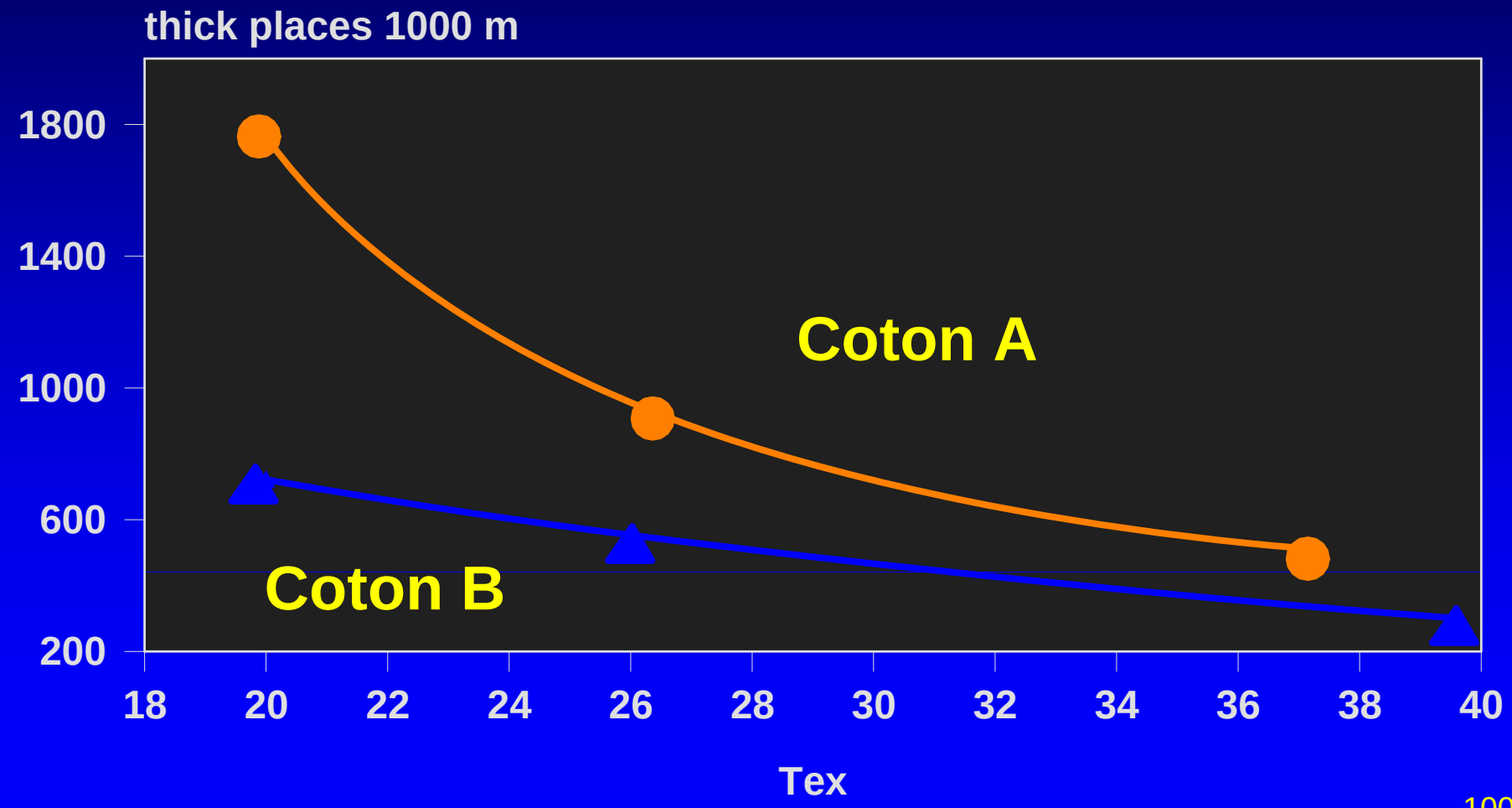
Relations between yarn versus fiber quality

CRL yarn tenacity tests (RS)



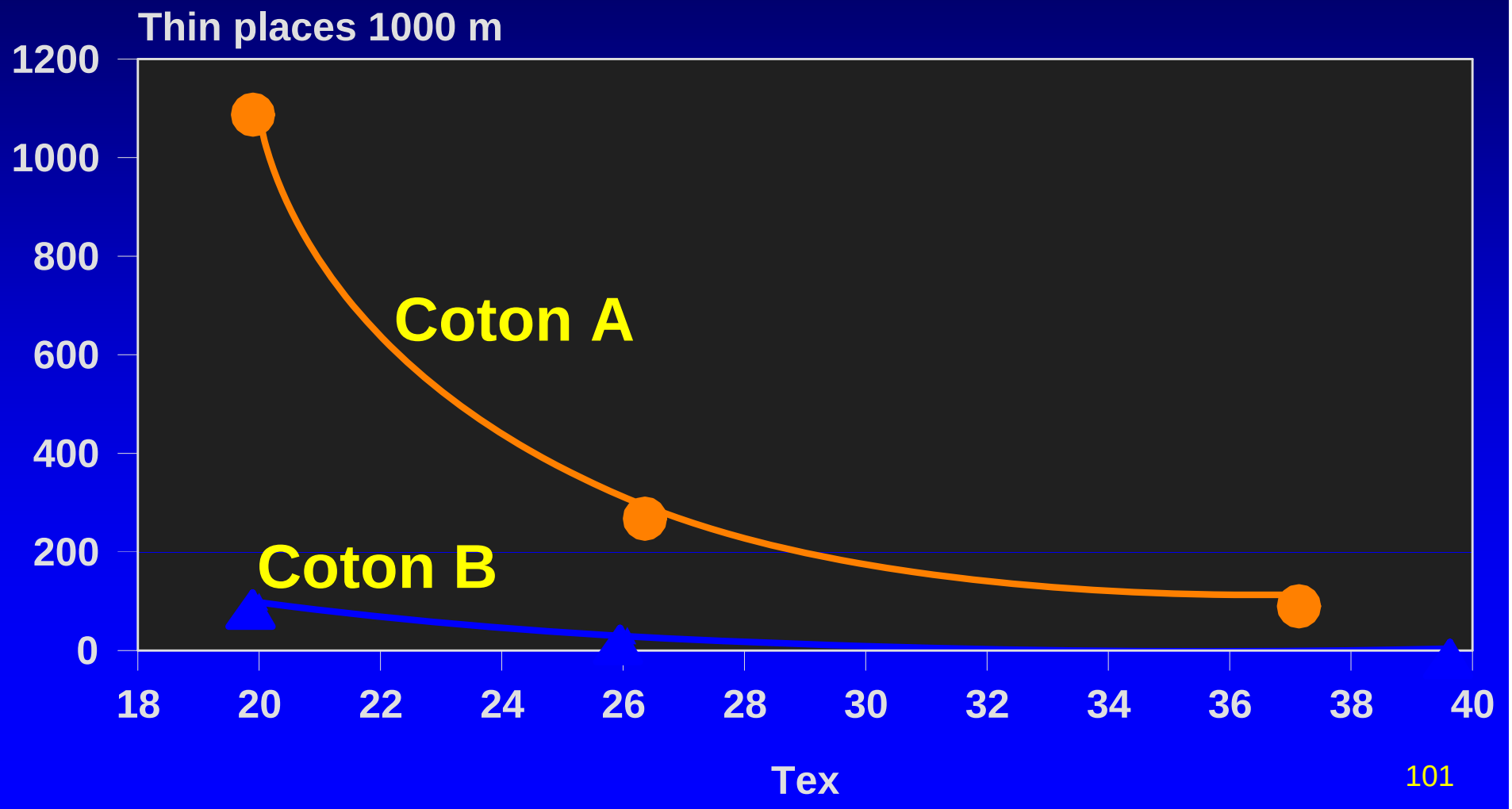
Relations between yarn versus fiber quality

Eveness tester UT3 : thick places (RS)



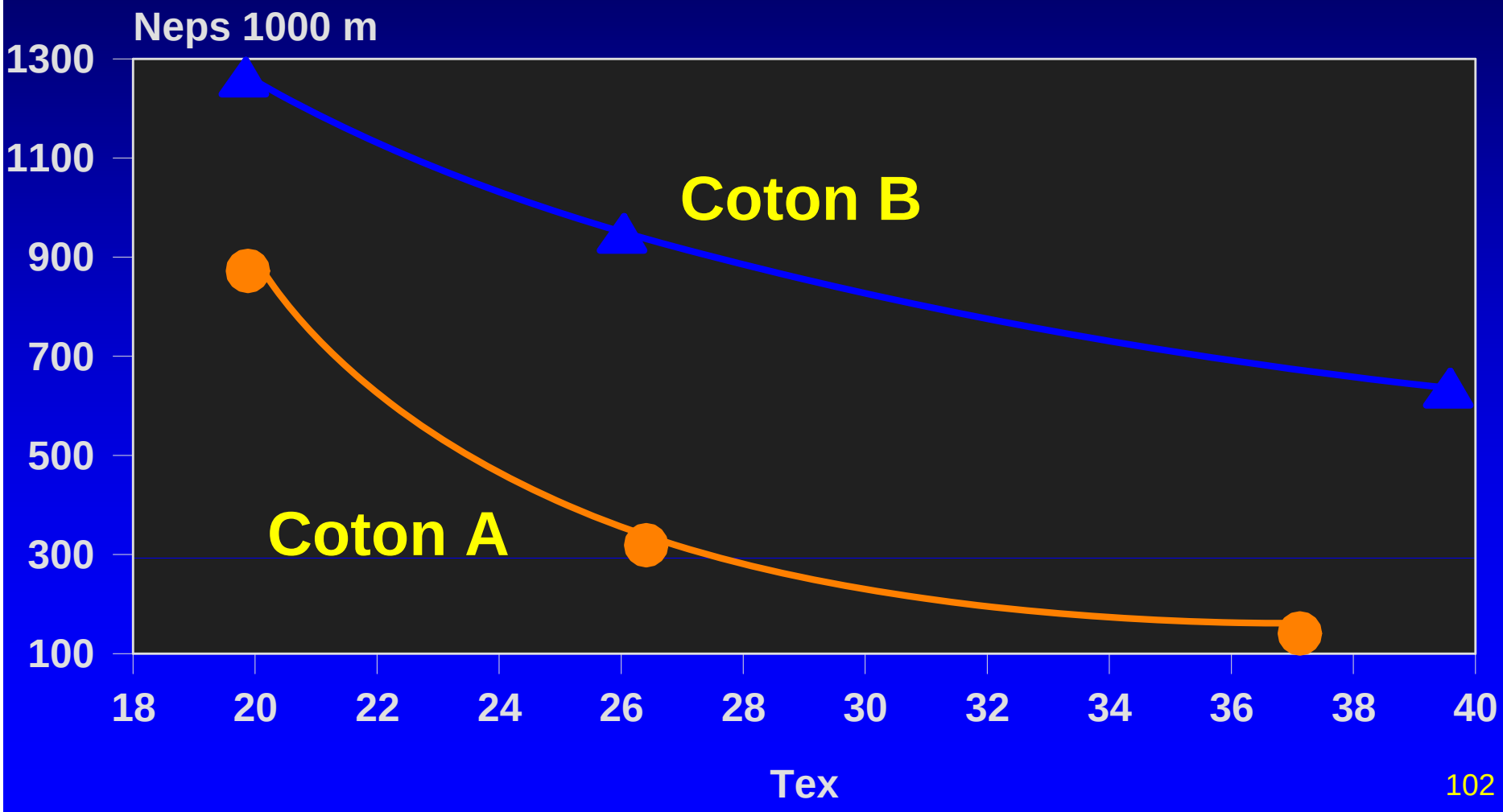
Relations between yarn versus fiber quality

Eveness tester UT3 : thin places (RS)



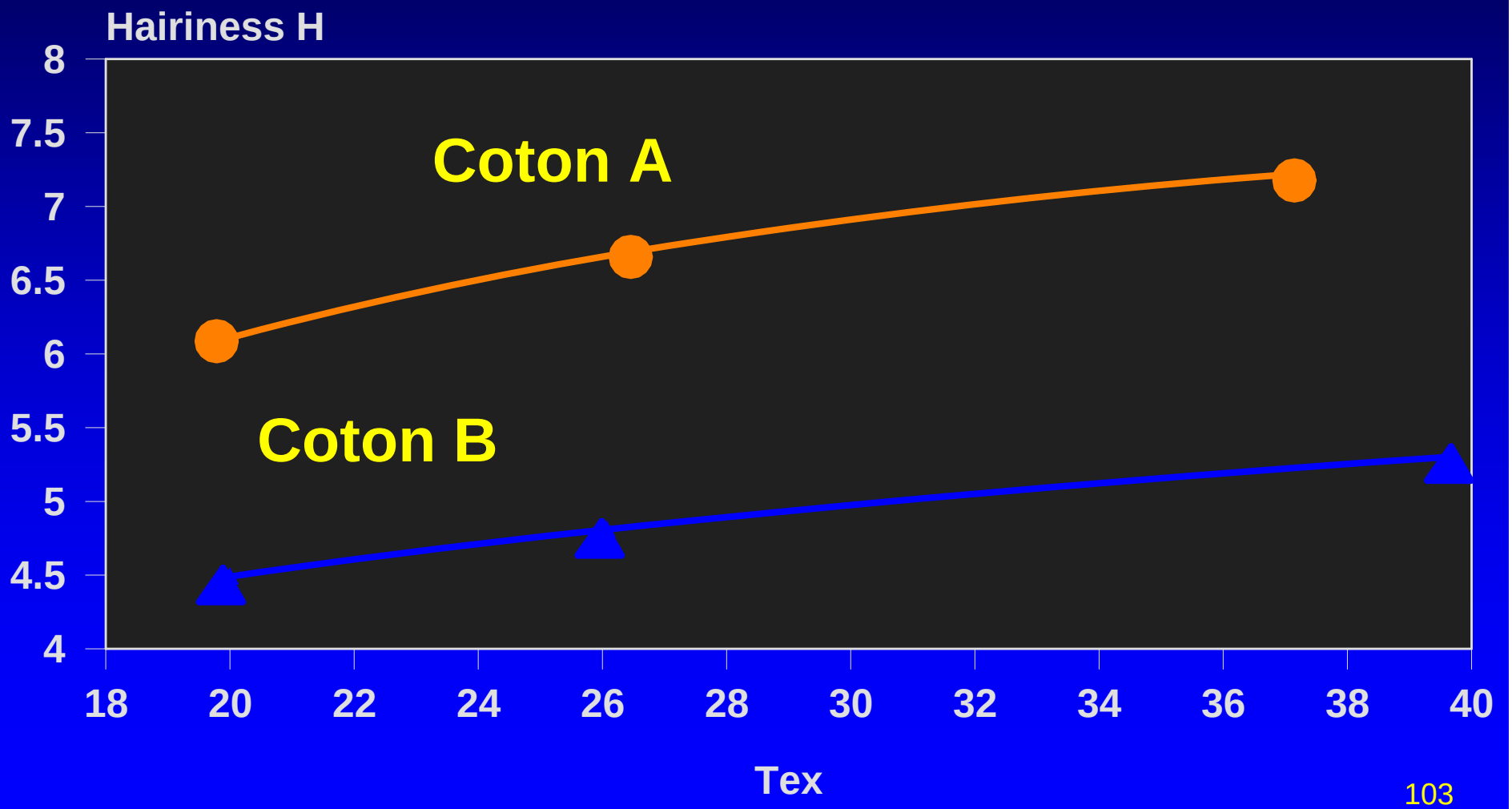
Relations between yarn versus fiber quality

Eveness tester UT3 : neps places (RS)



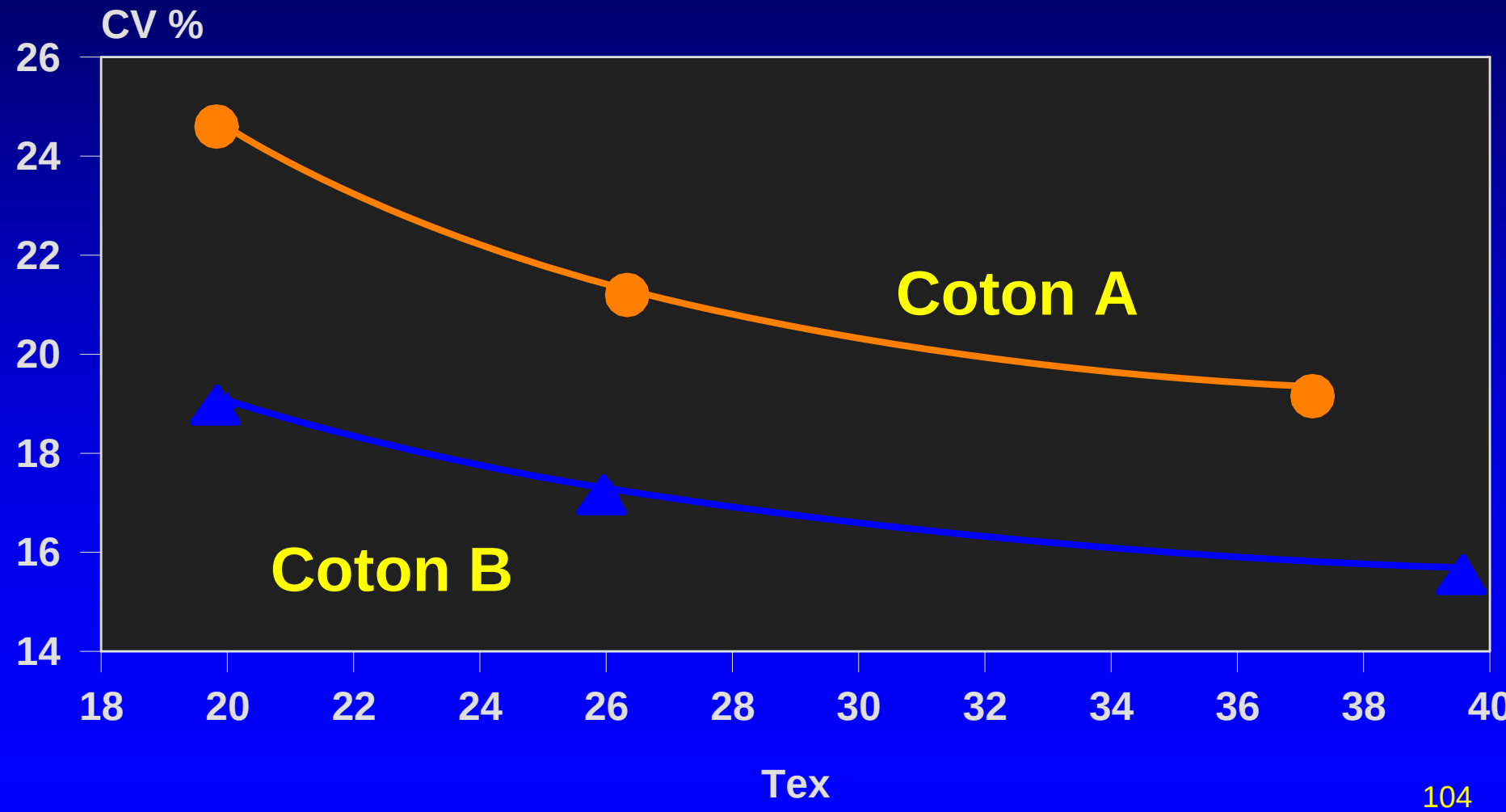
Relations between yarn versus fiber quality

Eveness tester UT3 : hairiness (RS)

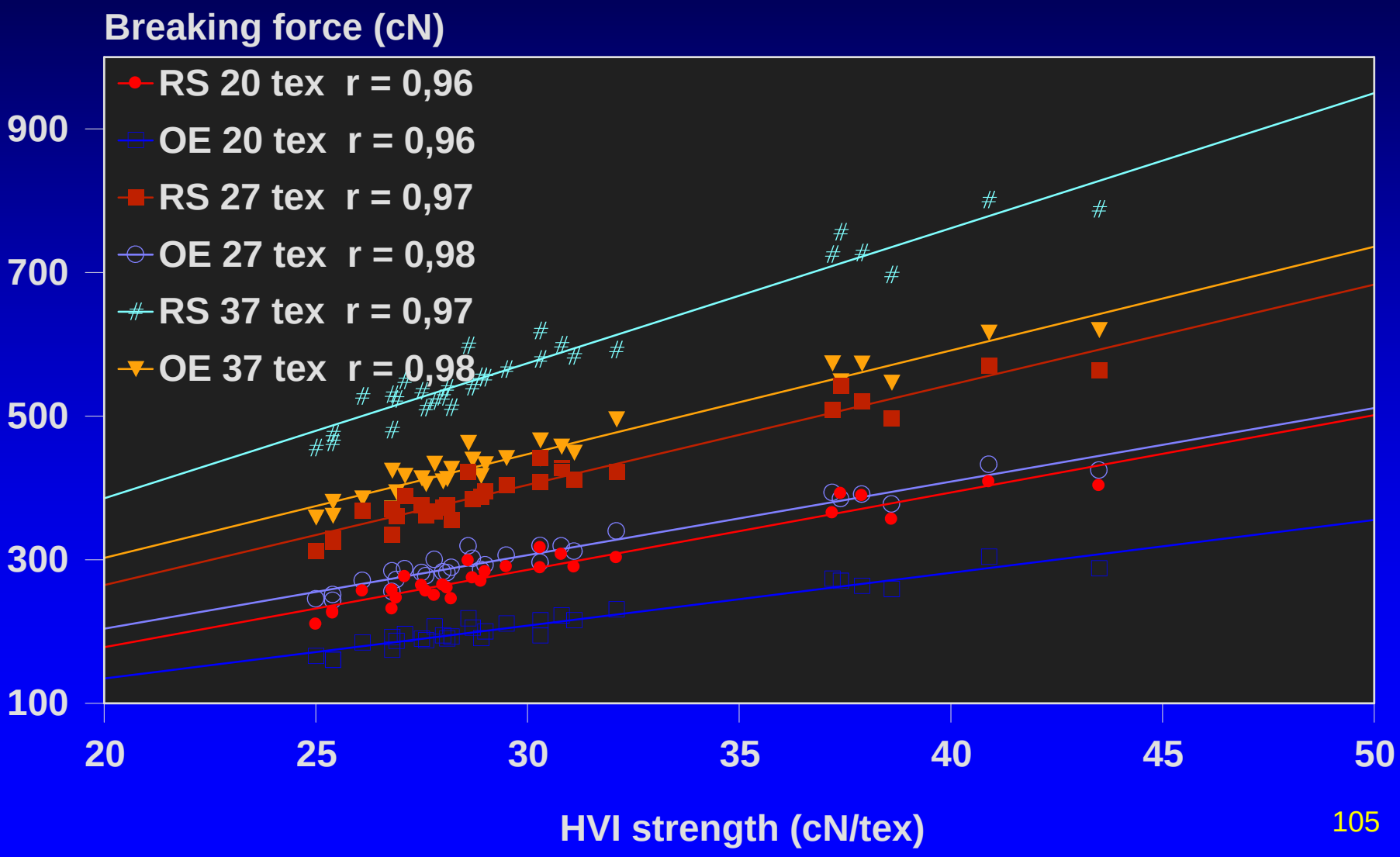


Relations between yarn versus fiber quality

Eveness tester UT3 : CV% (RS)



Relations between yarn versus fiber quality



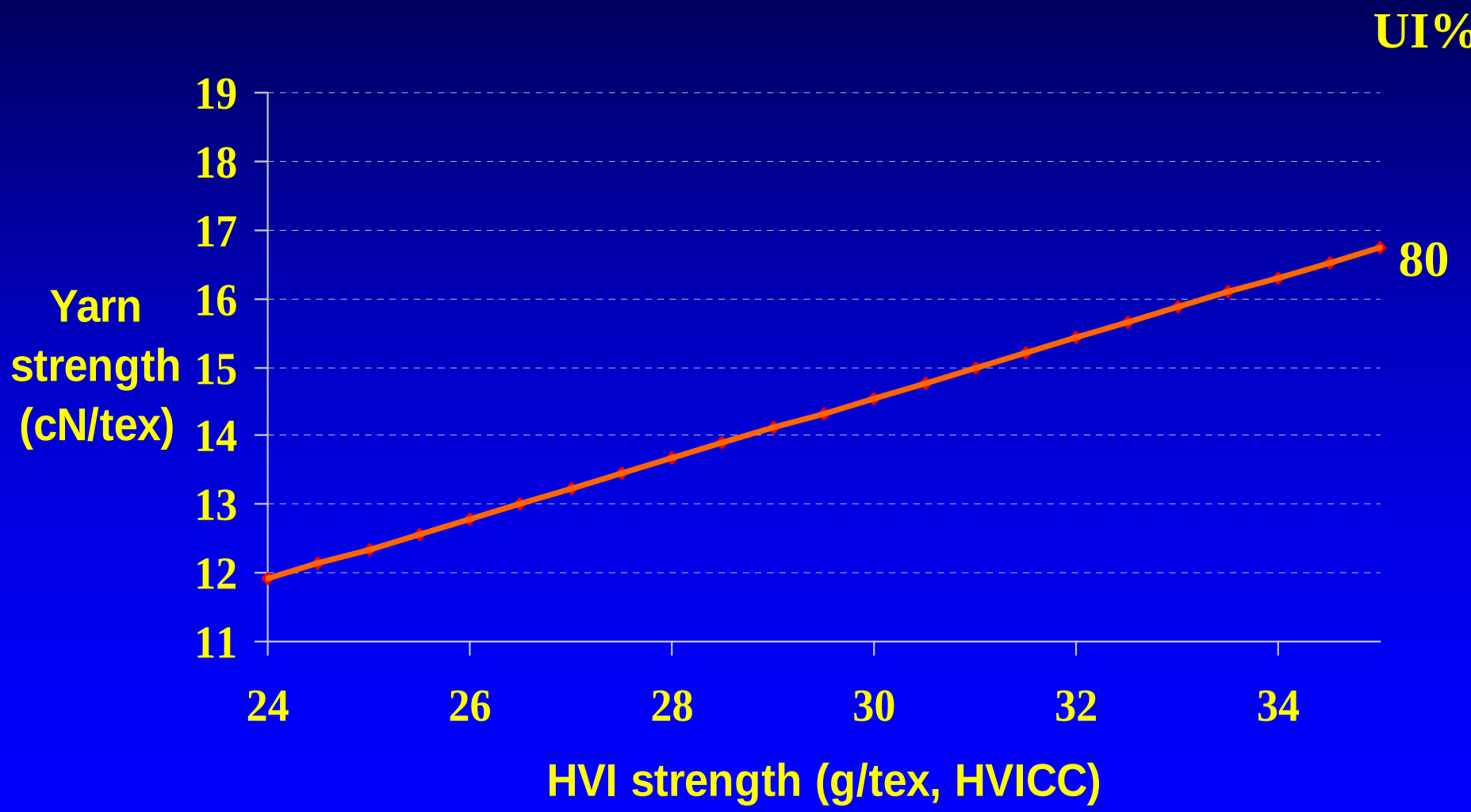
Effect of fibre parameters on yarn resistance

- 191 cottons from various origins
- Fibre analysis + spnning RS 20tex

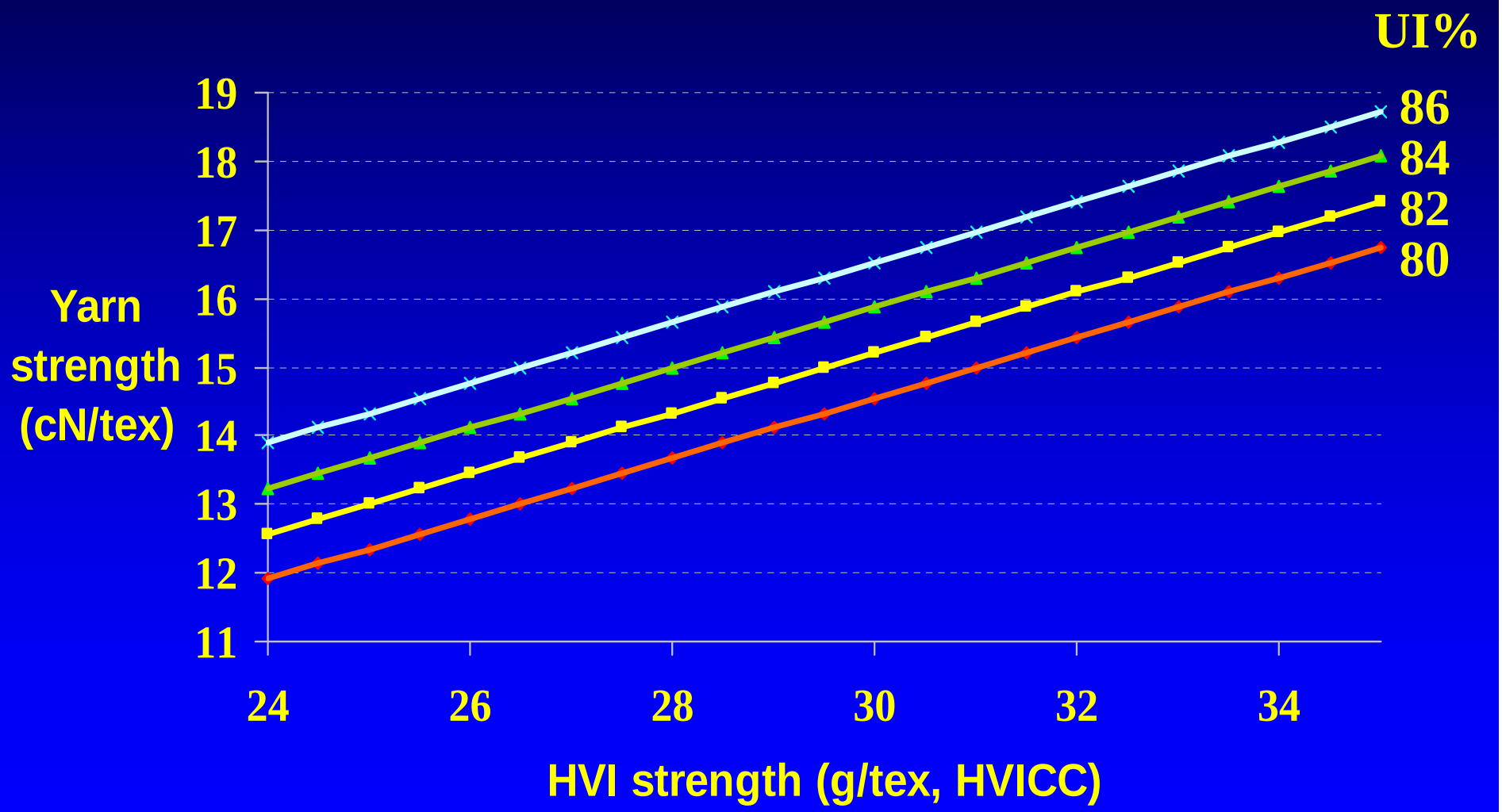
Ten Fil = 0.44 TenHVI - 0.0016 H + 2.58 MR + 0.33 UI - 27.03

R^2 = 0.76 ***

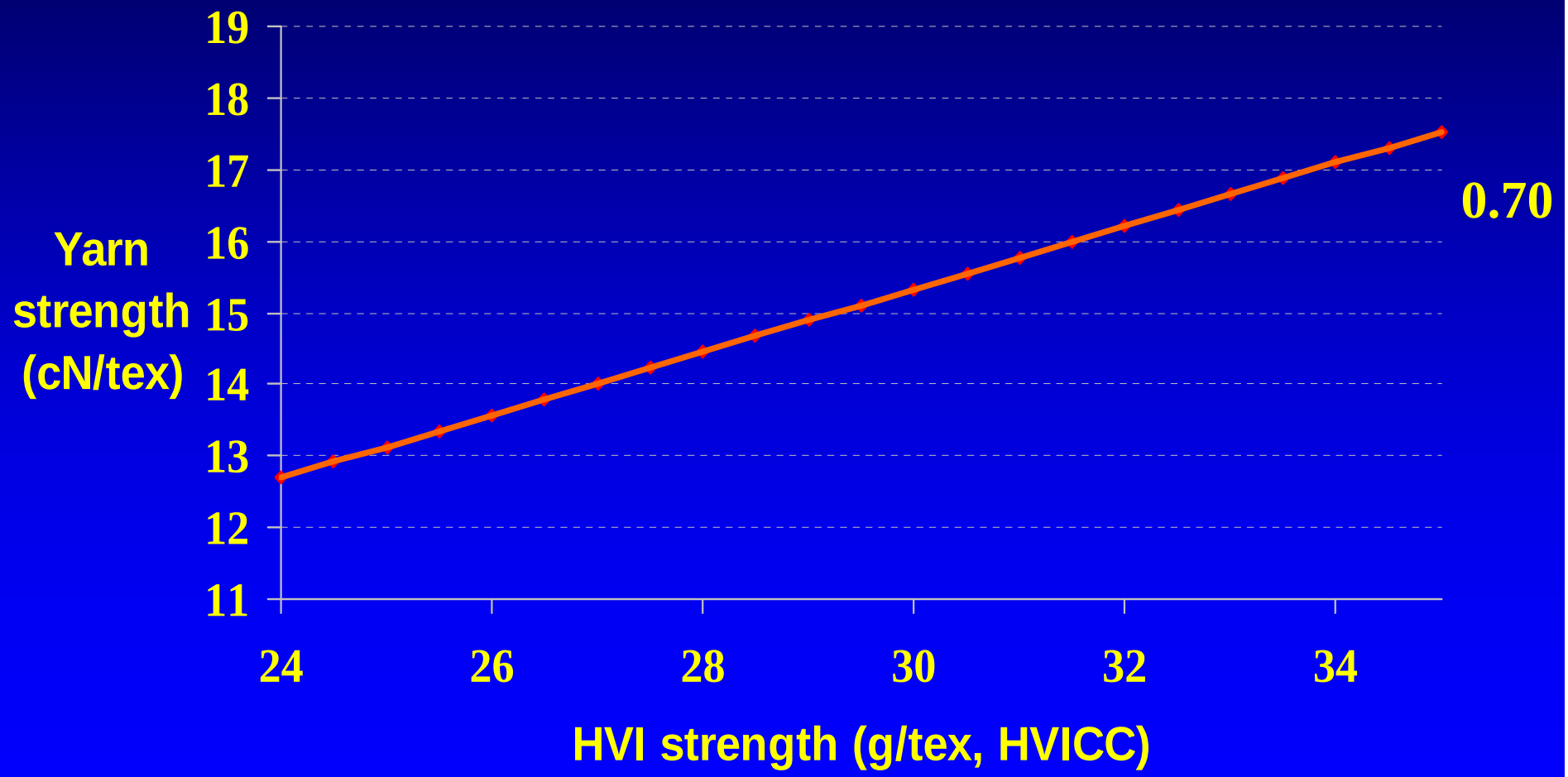
Fibre strength and UI vs yarn strenght RS 20 tex



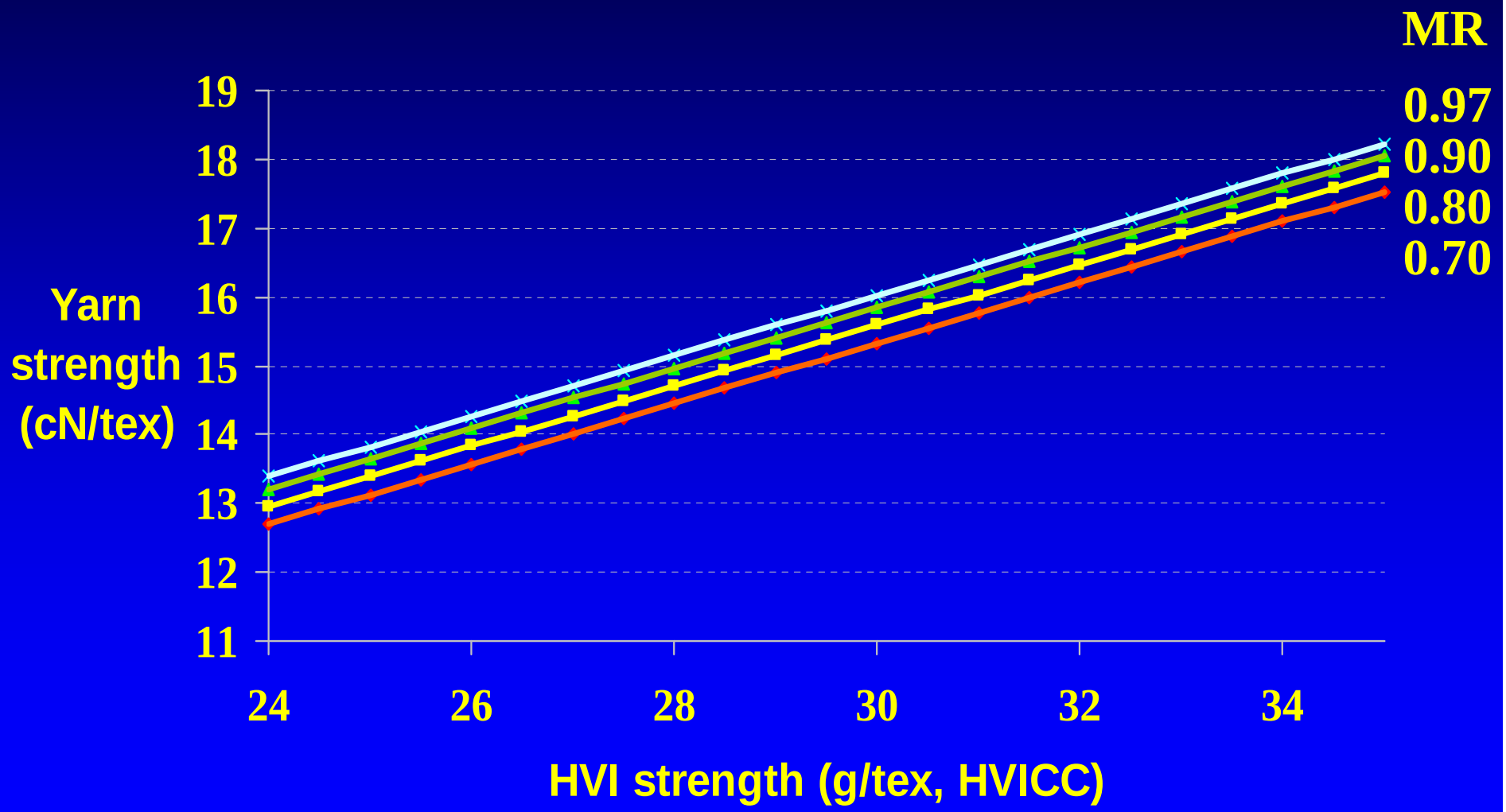
Fibre strength and UI vs yarn strenght RS 20 tex



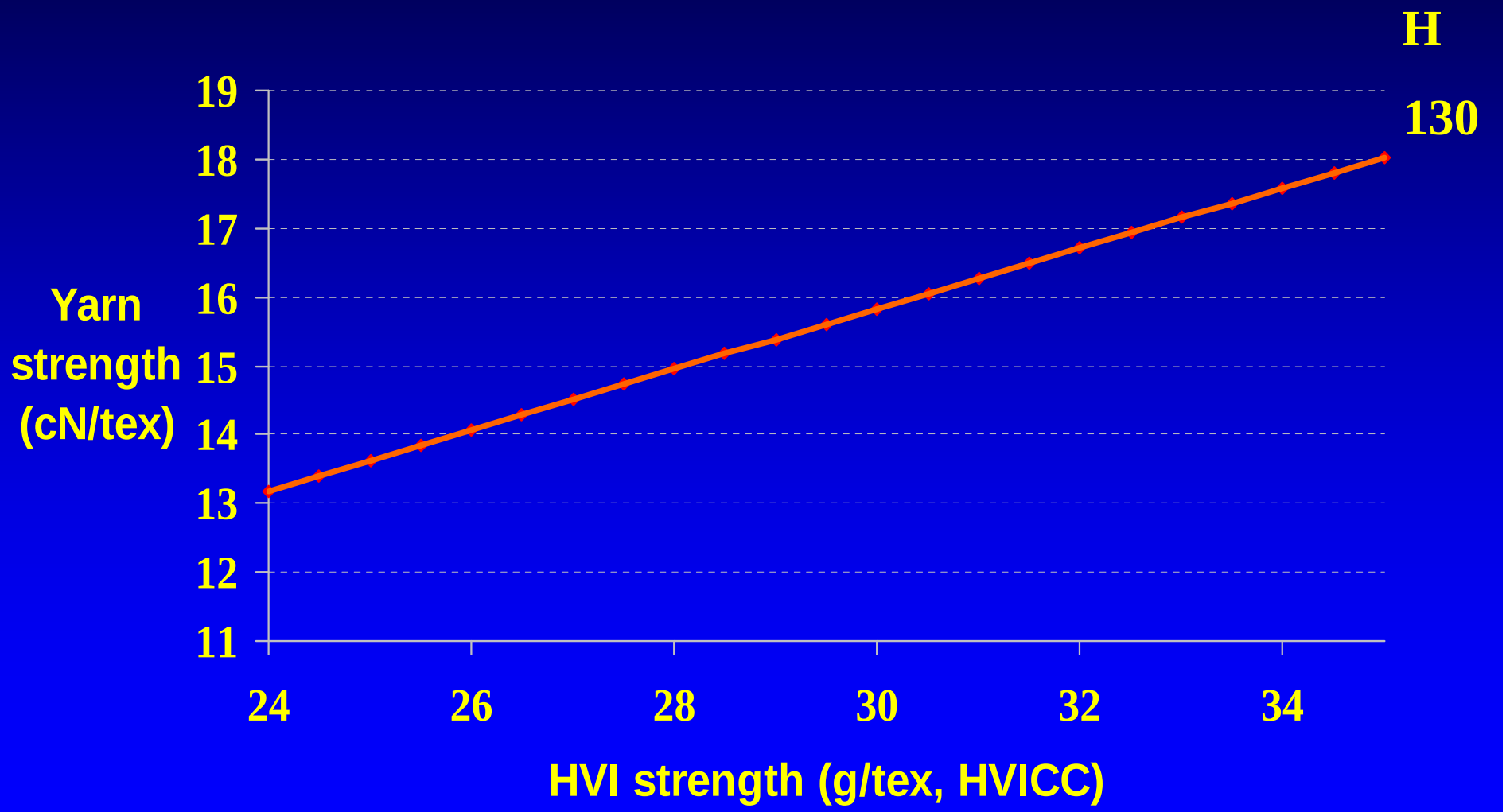
Fibre strength and MR vs yarn strenght RS 20 tex



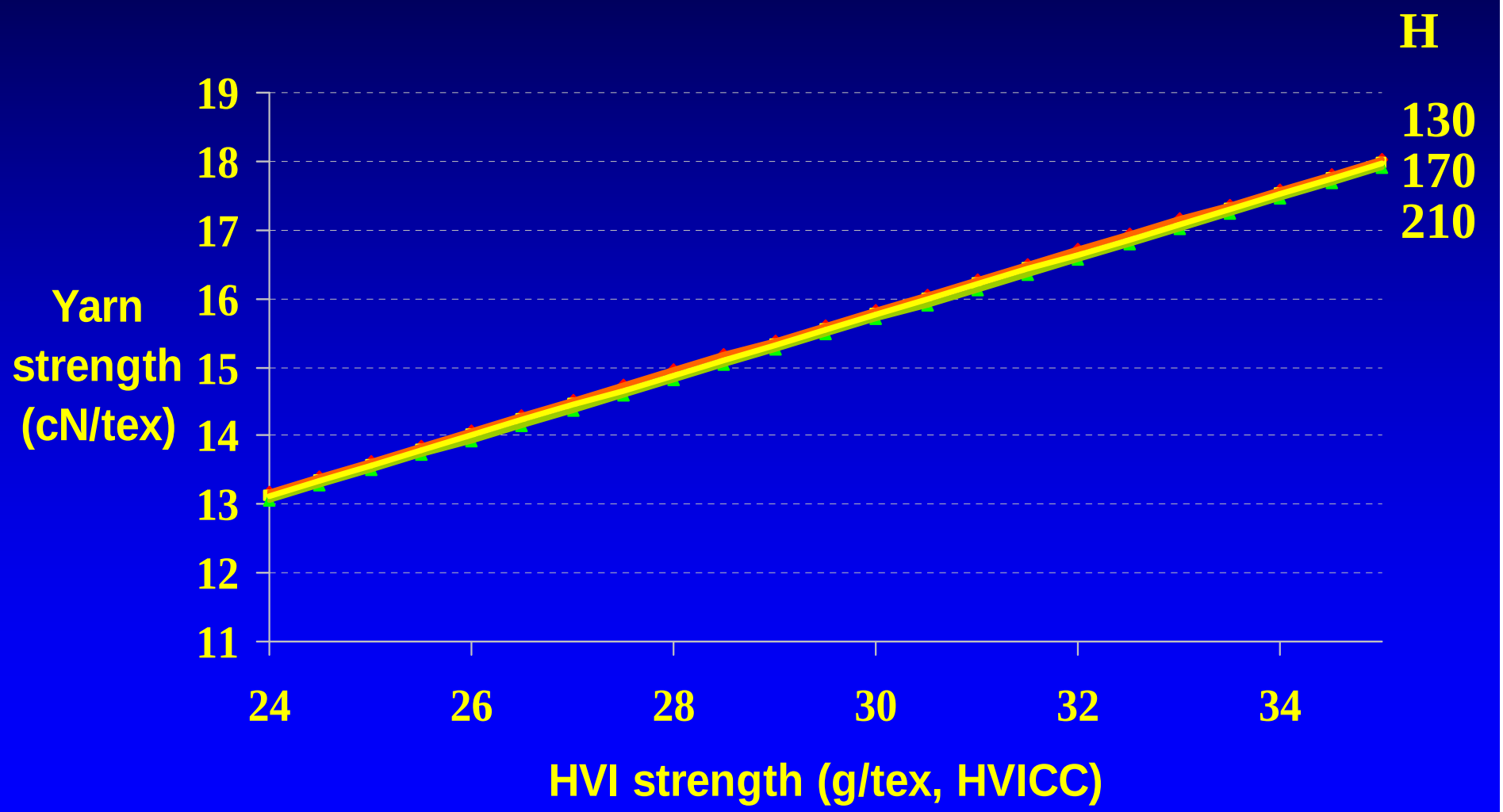
Fibre strength and MR vs yarn strenght RS 20 tex



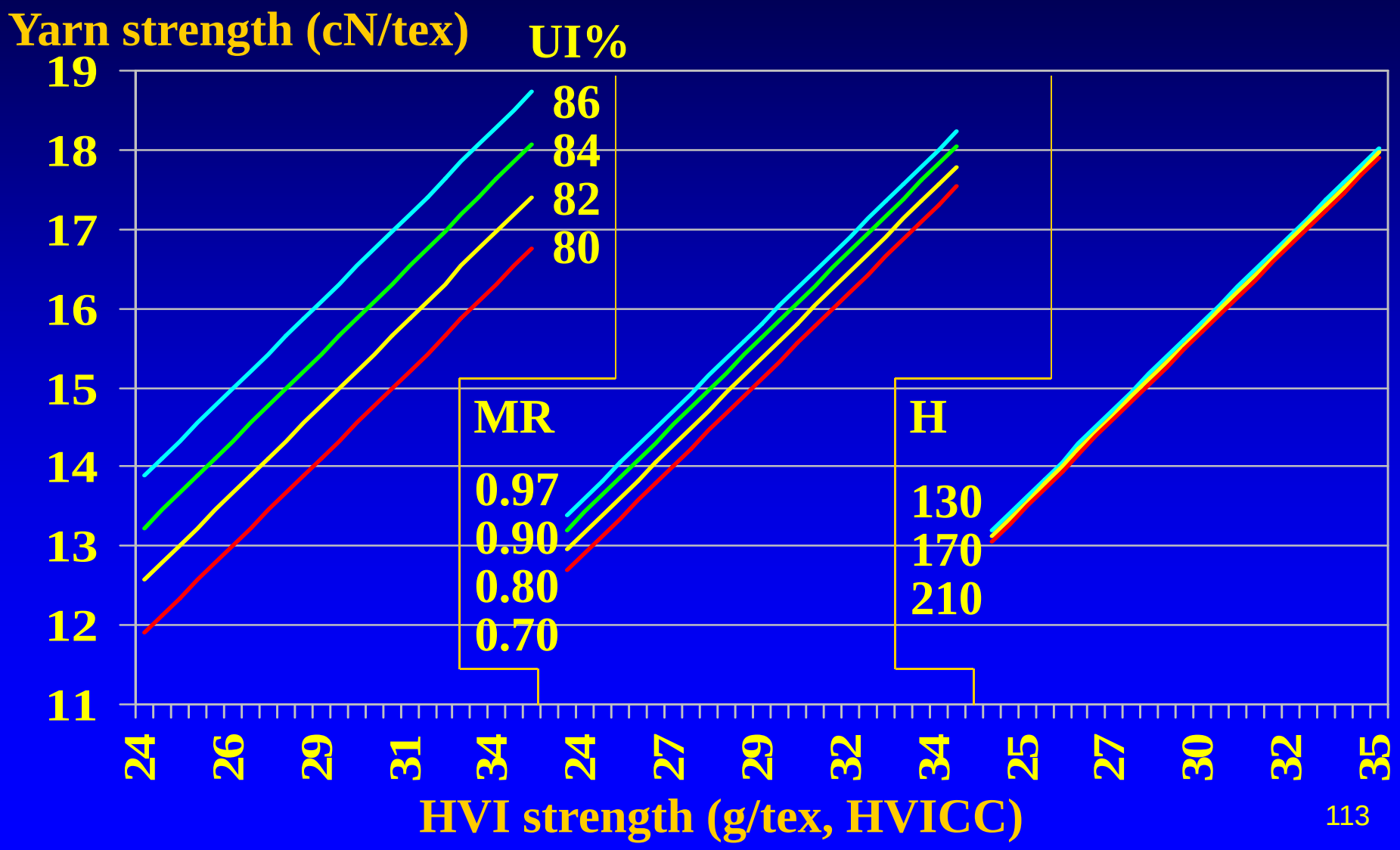
Fibre strength and H vs yarn strenght RS 20 tex



Fibre strength and H vs yarn strenght RS 20 tex



Fibres characteristics vs yarn strenght RS 20 tex



Fibres characteristics vs yarn eveness RS 20 tex

- 30 cottons
- Fibres characterization
- Spinning OE 20, 27 and 37 tex
- Spinning RS 20, 27 and 37 tex

Correlations coefficients between fibres characteristics and OE yarn eveness

		ML	UHML	UI	ST	EL
Thin pl. (FIN)	20 tex	-0.55	-0.58	-0.33	-0.62	-0.43
Thick pl. (GRO)	"	-0.34	-0.37	-0.12	-0.34	-0.20
Neps (NEP)	"	-0.25	-0.28	-0.10	-0.26	-0.22
CV evenness (CVR)	"	-0.62	-0.63	-0.48	-0.60	-0.49
Hairiness (PIL)	"	-0.63	-0.61	-0.60	-0.55	-0.59
FIN	27 tex	-0.54	-0.57	-0.33	-0.52	-0.41
GRO	"	-0.32	-0.35	-0.12	-0.29	-0.25
NEP	"	-0.29	-0.32	-0.10	-0.28	-0.27
CVR	"	-0.39	-0.40	-0.27	-0.27	-0.34
PIL	"	-0.57	-0.56	-0.52	-0.52	-0.41
FIN	37 tex	-0.43	-0.44	-0.32	-0.34	-0.30
GRO	"	-0.39	-0.41	-0.23	-0.28	-0.34
NEP	"	-0.25	-0.29	-0.03	-0.21	-0.17
CVR	"	-0.29	-0.28	-0.29	-0.21	-0.26
PIL	"	-0.65	-0.64	-0.59	-0.49	-0.62

Correlations coefficients between fibres characteristics and RS yarn eveness

		ML	UHML	UI	ST	EL
Thin pl. (FIN)	20 tex	-0.75	-0.70	-0.86	-0.68	-0.71
Thick pl. (GRO)	"	-0.85	-0.81	-0.87	-0.78	-0.81
Neps (NEP)	"	-0.60	-0.61	-0.42	-0.51	-0.60
CV evenness (CVR)	"	-0.89	-0.86	-0.89	-0.82	-0.83
Hairiness (PIL)	"	-0.72	-0.66	-0.86	-0.64	-0.73
FIN	27 tex	-0.71	-0.66	-0.85	-0.64	-0.67
GRO	"	-0.82	-0.80	-0.79	-0.75	-0.79
NEP	"	-0.49	-0.53	-0.24	-0.41	-0.48
CVR	"	-0.90	-0.87	-0.90	-0.84	-0.85
PIL	"	-0.68	-0.62	-0.84	-0.64	-0.72
FIN	37 tex	-0.66	-0.60	-0.82	-0.58	-0.60
GRO	"	-0.81	-0.79	-0.74	-0.73	-0.75
NEP	"	-0.47	-0.51	-0.20	-0.40	-0.43
CVR	"	-0.90	-0.86	-0.90	-0.83	-0.84
PIL	"	-0.71	-0.66	-0.86	-0.64	-0.75

Plan of presentation

- Introduction
- Different ways of fibers characterization
- A point about the standardization process
- How does work an HVI
- An example of relation between fiber and yarn quality
- **Conclusions**

Conclusion

HVI cotton fiber measurements may be used to :

- **Commercialy characterize cotton fibers properties**
  - standardization ongoing for all measured parameters
  - future evolutions to integrate new properties characterization
  - that may induce new rules in the trade

Conclusion

HVI cotton fiber measurements may be used to :

- **Arrange laydowns to stabilize or control :**
  - mean values
  - variability around those mean values according to production means (from field to ginning mill), sampling procedures (from ginning to spinning mills) …

Conclusion

HVI cotton fiber measurements may be used to :

- **Predict the fiber behavior in the processing steps both in terms of :**
  - quality
  - productivity

Conclusion

HVI cotton fiber measurements may be used to :

- **Control,**
- **Check,**
- **And set spinning machineries**

to get the highest yarn quality as demanded by the market

Conclusion

HVI cotton fiber measurements may be used to :

- **Breed new varieties depending on the improvements made in the transformation stages.**

depending on commercialy recognised characterization

What Cirad does and recommends

1) Apparatus calibration to insure a proper reading level.

2) Check and set-up of procedures to warrant proper precision and accuracy levels.

3) Check of the results through a participation to periodical international round tests.

4) Check the precision in classing routine.

TO GET

- Homogeneous results on the cotton market
- Limited number of claims.

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Thank you

for your attention